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PHYSICS ABSTRACTS

SECTION A

of

SCIENCE ABSTRACTS

SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

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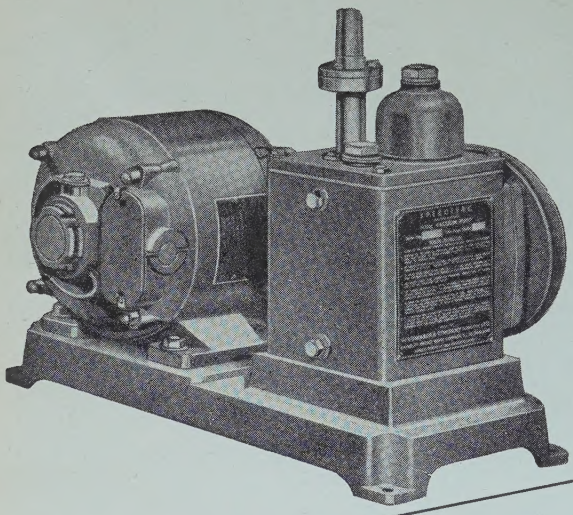
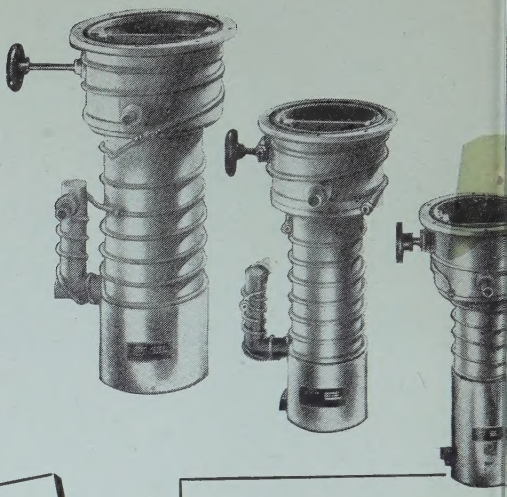
ABSTRACTS 1–969

VOLUME 57 **JANUARY 1954** NUMBER 673





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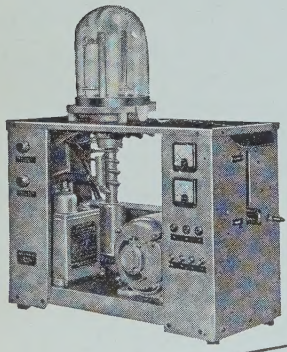

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RELATED SUBJECTS CONTAINED IN SECTION B (ELECTRICAL ENGINEERING ABSTRACTS)

Electrical and magnetic measurements and instruments
Electronic relays and counters
Automatic control mechanisms
Applied electrochemistry
Photocells
Thermionic tubes
Cathode-ray tubes
X-ray tubes
Amplifiers
Radiocommunication
Mechanical engineering
Illumination

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 56 (195 and the Supplement published with the Index to Volume 56 (1953). Reprints of the List of Journals (1953) c be obtained from the Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. 0d. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted f errors.

Aeronaut. Res. Coun. (Min. of Supply), Rep. Mem.	*Aeronautical Research Council (Ministry of Supply) Reports a Memoranda.* Her Majesty's Stationery Office, Kingsway, Londo W.C.2.
Bull. Fac. Engng Yokohama Nat. Univ.	*Bulletin of the Faculty of Engineering of Yokohama National Universi* Faculty of Engineering, Yokohama National University, Yokohama
J. rational Mech. Anal.	*Journal of Rational Mechanics and Analysis.* [Abstracted by the Brit Society of Rheology.]
Proc. West. Comput. Conf. Los Angeles, 1953	*Proceedings of the Western Computer Conference, Los Angeles.* Instit of Radio Engineers, 1 East 79th Street, New York, 21, N.Y.

New Journals

Arch. elektrotech. [*Warsaw*]	*Archiwum Elektrotechniki.* Polska Akademia Nauk, Politechnika-Zak Elektroniki, 75 Koszykowa, Warsaw. Volume 1, No. 1 dated 1952
Rev. E.	*Revue E.* Société Belge des Electriciens, 1 Place du Trône, Brussels. Volume 1, No. 1 dated 1953.

Notes

The journal formerly listed as *Arch. Elektrotech.* will now appear as *Arch. Elektrotech.* [*Berlin*].

Vacuum. Address changed to Manor Royal, Crawley, Sussex, England.

Errata

Author Index (1950), p. 1087, column 1, line 82: *for* TONKER, T. L. H. *read* JONKER, J. L. H.
line 83: *for* 8084 *read* 8048.
p. 1118, column 2, line 3: *for* 8084 *read* 8048.
Abstr. 9659 (1951), line 3: *for* **32** *read* **23.**
for (1591) *read* (1951).
Abstr. 9660 (1951), line 3: *for* **32** *read* **23.**
Abstr. 4113 (1953), line 3: after **38** insert *No.* 5.

Corrections to Articles

Corrections have been published, as shown below, to the articles whose abstract numbers are given. Unless ot wise stated, the volume and page given refer to the journal named in the abstract, i.e. the journal in which the orig article was published.

Abstr. 8048 (1950): **8,** 397 (*Oct.*, 1953).
Abstr. 5860 (1952): **24,** 1335 (*Oct.*, 1953).
Abstr. 1034 (1953): **91,** 1580 (*Sept.* 15, 1953).
Abstr. 3632 (1953): **21,** 2097 (*Nov.*, 1953).
Abstr. 4782 (1953): **24,** 1334 (*Oct.*, 1953).
Abstr. 5369 (1953): No. 45, 39 (*Sept.*, 1953).
Abstr. 5646 (1953): No. 46, 43 (*Nov.*, 1953).
Abstr. 6176 (1953): **91,** 1580 (*Sept.* 15, 1953).
Abstr. 7091 (1953): **91,** 1580 (*Sept.* 15, 1953).
Abstr. 7093 (1953): **91,** 1580 (*Sept.* 15, 1953).
Abstr. 7776 (1953): **237,** 675 (*Sept.* 28, 1953).
Abstr. 7870 (1953): **91,** 1580 (*Sept.* 15, 1953).

MATHEMATICS 51

517.512.5

1. The summation of series involving roots of transcendental equations and related applications. M. R. SPEIGEL. *J. appl. Phys.*, **24,** 1103–6 (*Sept.*, 1953).

The summation of series involving the roots of certain transcendental equations having real roots is achieved by elementary considerations. The method is illustrated by several examples representative of those which may arise in applications. In addition to summing series, the method can be used to obtain the least positive root of the transcendental equation to any desired accuracy with but little computation. A.

517.8

2. A note on the Airy-integral function. K. G. BUDDEN. Note in *Proc. Cambridge Phil. Soc.*, **49,** *Pt* 3, 574–7 (1953).

Three physical examples are given of situations in which the function arises. One of these occurs in light optics, the second in radio optics, the third in the theory of propagation of waves through a homogeneous dispersive non-absorbing medium.

L. S. GODDARD

518.5

3. Programme design for the C.S.I.R.O. Mark I computer. I. Computer conventions. T. PEARCEY AND G. W. HILL. *Austral. J. Phys.*, **6,** 316–34 (*Sept.*, 1953).

The organization of the computer is described. The code system is of a two-address type in which each operation called by an "order" or "command" is thought of as a quality of a transfer of the content of one "register" to another. Each command indicates a source and a destination. A special notation of mnemonic type is adopted for written programmes as an aid in the various stages of programme design. The written programme may be translated, by aid of a special encoding key-punch, from the written sheet on to paper tape, the medium through which the machine accepts data. A.

518.5

4. Programme design for the C.S.I.R.O. Mark I computer. II. Programme techniques. T. PEARCEY AND G. W. HILL. *Austral. J. Phys.*, **6,** 335–56 (*Sept.*, 1953).

The general structure of typical programmes is considered in relation to the structure of the computer, in particular to its facilities which tend to render programmes invariant with regard to their position in the store. Full-scale programmes are constructed by piecing together by a master programme a suitable selection of items from a library of "standard routines." The library contains "sub-routines" which are completely self-contained and require no additional information for their operation and are invariant with respect to their position in the store, and "routines" which are not so invariant and frequently require additional data to be provided during their entry into the store. The entry of special data for routines and the simplification of the construction of the master programme are facilitated by a special routine used whilst the entire programme is being entered into the store. A.

518.5

5. Test for zeros in the unit circle. L. WEINBERG. Letter in *J. appl. Phys.*, **24,** 1251–2 (*Sept.*, 1953).

It is demonstrated that a computationally simple and useful test for the stability of a pulsed-data system is given by a bilinear transformation and the continued-fraction form of the Hurwitz test.

J. M. C. DUKES

518.5 : 621.318.572

6. Digital computers at Manchester University. T. KILBURN, G. C. TOOTILL, D. B. G. EDWARDS AND B. W. POLLARD. *Proc. Instn Elect. Engrs II,* **100,** 487–500 (*Oct.*, 1953).

For abstract, see Abstr. 6990 (1952).

518.5 : 621.318.572

7. Universal high-speed digital computers: a decimal storage system. T. KILBURN AND G. ORD. *Proc. Instn Elect Engrs II,* **100,** 513–22 (*Oct.*, 1953).

For abstract, see Abstr. 6241 (1952).

518.5 : 621.317.79

8. Calculating apparatus with linear potentiometers. A. P. SPEISER. *Z. angew. Math. Phys.*, **3,** *No.* 6, 449–60 (1952) *In German.*

Gives circuits that may be used in computing instruments using only resistances and linear potentiometers. Pt 1 is a summary of the well-known methods of representing the elementary operations. Pt 2 is a discussion of curve fitting methods for functions of one variable. Pt 3 deals with curve fitting for functions of two variables; special use is made of the concept of hexagonal grid structure (*Sechseckgewebe*). Pt 4 gives some general remarks regarding the computing instruments. A.

518.5 : 681.142 : 621.317.79

9. Analog computer for the roots of algebraic equations. L. LÖFGREN. *Proc. Inst. Radio Engrs,* **41,** 907–13 (*July*, 1953).

An electronic analogue machine for computing the roots of algebraic equations of degrees through the eighth is described. The coefficients of the equation may be complex. The roots are indicated as points in the complex-number-plane light points on the screen of a c.r.t. Once per second the roots are displayed, and when some of the coefficients are varied the corresponding curves described by the roots are made visible by the persistence of light emission from the screen. An accurate determination of the roots is obtained by means of a comparison-root which can be moved all over the number plane and thus be brought to coincide with a root. The comparison-root is displayed by a scanning system, which also controls the positions of the roots, and so it is possible to obtain an accurate reading not influenced by distortion in the c.r.t. By means of a normalizing device, the voltage level in the machine is kept high throughout the computation, and so all the roots are determined with about the same % accuracy. The modulus of an error will normally be of the magnitude of 1% of the corresponding root-modulus. A.

ASTRONOMY . ASTROPHYSICS . GEODESY 52

523.161

10. Distribution function of cosmic particles of the primary component. Ya. P. Terletskii and A. A. Logunov. *Zh. eksper. teor. Fiz.*, **23,** *No.* 6 (12) 682–5 (1952) *In Russian.*

A study of the equation of diffusion of cosmic particles in the interstellar medium. The equation is obtained with the assumptions that the coefficient of diffusion is linearly dependent on the energy of the particles, and that the increase in the magnetic field, caused by the turbulent motion of the interstellar gas, produces acceleration of the particles. The solution of the simplified equation of diffusion, with the sources located nearer than some critical radius, gives an exponential distribution of the particles with respect to the energies. The exponential index is equal to 2·5 and is the same for protons and for ions.

E. RABKIN

523.161

11. The turbulence of interstellar space in emission. G. Courtès. *C.R. Acad. Sci.* [*Paris*], **237,** 378–80 (*Aug.* 3, 1953) *In French.*

Based on measures of radial velocity made with the aid of an interference H-filter, it is found that for the nebulous region around λ Orio the relative velocity, v, between two points in the cloud separated by L parsecs is given by the relation, $v = \mathrm{c}.L^{0.33}$, whilst for the Orion nebula, $v = c.L^{0.60}$. The "cell" dimensions of the turbulent gas in the two regions above-mentioned are found to be 8 parsecs, and 1 parsec respectively. These results are of similar order of magnitude to that predicted by Spitzer, and to that found for an emission region in Cygnus (10 parsecs) by Aller [Abstr. 3270 (1951)]. D. R. BARBER

523.162.2 : 523.852.3

12. The red shift in the spectra of distant nebulae. R. d'E. Atkinson. Letter in *Observatory*, **73,** 159–60 (*Aug.*, 1953).

H. S. Shelton has suggested that the shift might be explained by collisions between photons and elementary particles, energy being given to the particles only in the direction of motion of the photons. Atkinson indicates that momentum would not be conserved for such collisions and emphasizes that nebulae would be too diffuse to see if the red shift were due to a Compton effect. R. A. NEWING

523.165

13. Radio radiation from the supergalaxy. J. D. Kraus and H. C. Ko. Letter in *Nature* [*London*] **172,** 538–9 (*Sept.* 19, 1953).

An extended area of radio radiation at 250 Mc/s near R.A. 13^h, and Dec. $+15°$ to $-15°$, surveyed with the Ohio State radiotelescope, coincides closely with the known position and width of the local supergalaxy. D. R. BARBER

523.165 : 523.852

14. The Crab nebula as a radio source. J. L. Greenstein and R. Minkowski. *Astrophys. J.*, **118,** 1–15 (*July*, 1953).

The optical continuous spectrum of the Crab nebula is rediscussed to ascertain whether the electron temperature in the amorphous mass can be very hig The level of ionization maintained by electr impacts is given. The optical radiation might persi even without a central star. Certain nuclear reactio in a "collapsed" star might produce excess Li and broadened lines of ionized carbon should be searche for in the spectrum of the amorphous mass. T thermal emission at radio frequencies is computed the basis of Elwert's evaluation of the logarithm term in the free-free opacity. The Crab nebula found to be optically thick below 100 Mc/s. It is n possible to reconcile the observed radio flux fro Taurus A with the optical flux at any temperature; t thermal emission is about one-ninetieth of t observed radio flux. Any non-thermal radio-gene tion process, like those in other gaseous "poi sources," will have its energy distribution chang by the opacity of the surrounding ion-electron clou Models in which non-thermal sources suffer abso tion prove to have flattened energy distributions low frequencies, as does the radio source in the Cr nebula. The radio-frequency opacity of other ioniz hydrogen regions is found to be appreciable, and d tant non-thermal sources seen through bright H regions will also have flattened spectra. This opac is proportional to the "emission measure" of region; the Orion nebula, planetary nebulae, and lo paths through weak H II regions are optically thi The Orion nebula should be detectable as a therm emitter at high frequencies; H II regions toward galactic centre may also be detectable in a narr range of galactic latitude.

52

15. Recent Soviet theories on the origin of the so system. A. Lebedinsky. *J. Brit. Astron. Assoc.*, 274–7 (*July*, 1953).

A review of Soviet researches on the birth of solar system carried out during the last decade, cluding *inter alia* the cosmogonic theory of O. Schmidt (1944) in which the pre-planetary clou formed of cosmic gas and dust captured by the during the latter's passage through an extens rarefied nebula. Of the various theories which h emerged in the past 150 years, Schmidt's hypoth can alone explain the main features of the s system as now observed. In comparison with ea work, an essential distinction of the new theory quantitative assessment of the part played by the version of the kinetic energy of the dust particles heat, and the subsequent emission into space.

D. R. BA

52

16. A possible origin of the violet layer in Martian atmosphere. B. Rosen. Note in *Astrophys.*, **16,** *No.* 4, 288–9 (1953) *In French.*

Alternative explanations of the violet "haze-la in the Martian atmosphere postulate either ice solid CO_2 crystals as the scattering medium. suggestion is made that a new interpretatio probable, namely, that the observed light-scatt caused by carbon-smoke particles [see Abstr (1954)]. D. R. BA

523.45/.46

17. Variations in atmospheric absorption over the disks of Jupiter and Saturn. S. L. Hess. *Astrophys. J.*, **118**, 151–60 (*July*, 1953).

Variations in the strength of absorption of methane at 6190 Å on Jupiter and Saturn, and ammonia at 6441 Å on Jupiter, were studied. The absorptions decrease slightly toward the edges of Jupiter, but increase somewhat toward the edges of Saturn. The conclusion is drawn that the cloud surface on Jupiter rises toward the limbs, but is more nearly level on Saturn. The ammonia results indicate a decrease in temperature from equator to poles on Jupiter. The morning limb is found to be cooler than the evening limb. A.

523.5

18. Radio echo studies of meteor ionization. T. R. Kaiser. *Advances in Phys.*, **2**, 495–544 (*Oct.*, 1953).

A summary is given of the contributions of radar methods of investigation to the study of the physics of meteors and their interaction with the atmosphere; meteor orbital studies are explicitly omitted. Theoretical studies are made of the processes of meteor ionization and its dissipation (by diffusion, recombination and attachment of electrons to oxygen molecules). The theory of the scattering of radiation by meteor trails, including Fresnel diffraction and "head echoes," is compared with experiments which include the use of polarized beams. The small value of the observed recombination coefficient leads to the conclusion that the majority of ions present arise from the evaporated meteor atoms. Decay-type echoes are due to trails with an ionization density less than a critical value of $2{\cdot}4\times10^{12}$ cm^{-1}, while long-duration echoes arise from trails with greater ionization densities. Upper atmospheric winds cause fading and complex structure of long-duration echoes. In decay-type echoes, enhancement by plasma resonance may occur, while for long-duration echoes attachment is an important process of ionization dissipation. A comparison of radar and visual observations shows that the faintest visible meteor corresponds to conditions of critical ion density. The application of a hitherto unpublished theory of meteor height distribution yields a height/velocity correlation (in which no evidence for a difference in chemical composition between shower and sporadic meteors is found) and atmospheric density profiles which are compared with those derived from visual meteor observations and rocket sondes. The constants of the meteor equation (including the ionization probability) are estimated in various ways, and the theory of echo rate so developed (hitherto unpublished) yields a mass distribution of the incident meteors in good agreement with visual observations of sporadic meteors; some evidence for selective Poynting–Robertson effect in well-established showers is presented. The effect of the instrumental parameters on the observed echo rate is discussed. A theoretical distribution of echo durations is compared with observations of the Perseid, Arietid and Geminid showers. The space density of meteors is deduced from the observed echo rates, and found to be insufficient to account for the zodiacal light unless (*a*) a large proportion of the interplanetary particles move in circular orbits, or (*b*) particles ~ 10 microns diameter are ~ 1000 times more frequent that would be predicted from the extrapolation of the observed mass distribution. If the latter hypothesis is correct, the influx of particles too small to be detected by radar methods could maintain the *E*-layer ionization.

M. W. OVENDEN

523.67 : 535.338.4

Observation of the 4050 Å group in a King furnace. *See Abstr.* 256

523.72

19. The distribution of radio brightness over the solar disk at a wavelength of 21 centimetres. II. The quiet sun—one-dimensional observations. W. N. Christiansen and J. A. Warburton. *Austral. J. Phys.*, **6**, 262–71 (*Sept.*, 1953).

For Pt I, see Abstr. 6422 (1953). Daily records of one-dimensional distribution of radio brightness over the sun are obtained in the way described in Pt I. When superimposed, these records show a well-marked lower envelope which remains substantially the same, in shape and size, over a period of months. This envelope gives the brightness distribution over the "quiet" sun. The direction of scan, with respect to the position of the solar axis, changes during a year by more than 50°. The very small change in shape of the envelope during this period suggests that for purposes of preliminary calculation the brightness distribution may be assumed to be circularly symmetrical. The radial distribution of brightness, calculated on this basis, is found to show marked limb-brightening and to be consistent with the calculated brightness distribution for a simple solar model in which the assumed values of temperature and density are close to those commonly accepted. A.

523.72

20. Evidence of harmonics in the spectrum of a solar radio outburst. J. P. Wild, J. D. Murray and W. C. Rowe. *Nature* [*London*] **172**, 533–4 (*Sept.* 19, 1953).

The characteristics of the spectrum of a radio burst associated with a solar flare was examined over the continuous range 38–220 Mc/s. At any instant, the radiation was concentrated into two widely-spaced frequency bands of comparable intensities, each showing the usual drift from high to low frequencies. The similarity of the fine-structure of the dynamic spectrum in the two bands suggests that both bands arose from the same emission source. The ratio of frequencies of corresponding features of the dynamic spectrum in the two bands lay between 1·90 and 2·00. These characteristics are supposed due to an original emission in harmonic frequencies f_3, $2f_0$, $3f_0$, . . ., with a strong intensity decrement, the fundamental f_0, corresponding to the natural plasma frequency, suffering considerable selective absorption. The height of the source at any instant was calculated from the low-frequency edge of the emission contour, using coronal electron densities from Baumbach and Allen. A constant gradient of 475 km/sec was found, which, when extrapolated to the time of start of the ultraviolet emission (indicated by a sudden diminution of cosmic noise), gave a height of origin of the source above the photosphere of $2{\cdot}5\times10^4$ km. A footnote refers to observations of a second outburst showing similar spectral characteristics. M. W. OVENDEN

523.74

21. The hydrogen convection zone of the sun. E. VITENSE. *Z. Astrophys.*, **32,** *No.* 3, 135–64 (1953) *In German.*

Detailed theoretical discussion of a model taking into account the interaction of convection and radiative transfer. The thickness of the convection zone is calculated to be between 65 000 and 160 000 km, according to the assumed type of mixing of the turbulent elements, i.e. of the length of path along which this mixing takes place. For the granulation elements on the solar surface velocities of 2–4 km/sec are derived (observed about 2·5 km/sec), and a mean life-time of about 2 min (observations gave 3–4 min). The calculated temperatures of the granules differ in the average by 300 deg, and at the most by 1000 deg, from that of their observable immediate surroundings. A. BEER

523.74

22. Difference of temperature between pole and equator of the sun. A. K. DAS AND K. D. ABHYANKAR. Letter in *Nature* [*London*] **172,** 496–7 (*Sept.* 12, 1953).

Bjerknes' thermo-hydrodynamical solar theory postulates higher temperatures at the poles than at the equator, the depth of a sunspot-vortex being connected with the magnitude of this temperature-difference. A test of this theory has been made by the aid of spectrophotometric measures of the equivalent widths of the 4227 Å line of neutral Ca, and the 3933 Å line of ionized Ca^+. From nearly 200 spectra taken at the solar poles and equator during a period of marked solar inactivity, the computed ionization-temperatures indicate a systematic difference of temperature in the expected direction of 92 ± 17 deg. Utilizing this result, a depth of 130 km is found for the sunspot-vortex. D. R. BARBER

523.742

23. The limb darkening in a grey atmosphere. G. RIGHINI AND M. RIGUTTI. *Mem. Soc. Astron. Ital.*, **24,** *No.* 3, 201–13 (1953) *In Italian.*

This has been calculated taking in account the blanketing effect. The darkening observed in total radiation for the solar atmosphere agrees fairly well with the theoretical results. A.

523.75

24. Eruptive prominence of February 26, 1953, and associated radio noise-burst. A. K. DAS AND K. SETHUMADHAVAN. *Nature* [*London*] **172,** 446–7 (*Sept.* 5, 1953).

Spectroheliographic and spectrohelioscopic observations of an eruptive prominence seen at the solar limb are reported. The prominence is classed as a "surge" of class IIId, although there was no associated sunspot or flare. The prominence showed a tendency to helical internal motions analogous to a tornado-type prominence, although it did not show the columnar characteristics usually associated with this latter type. Observations on 100 Mc/s showed three bursts, the weakest being simultaneous with the beginning of the eruption, when the prominence was entirely below 50 000 km above the limb, from which levels the 100 Mc/s radiation could not normally escape from the sun. The second burst occurred when the prominence was 140 000 km above th limb, and the strongest burst when it was at a heigh of 184 000 km. No fade-out or marked ionospheri disturbances associated with the eruption wer observed, but the period Feb. 22–March 4 was fa from magnetically quiet.

Radio observations at the time of an ascending sola prominence. R. D. DAVIES. *Ibid.*, 447–8.

Radio noise observations during the time of occu rence of the above eruption were made on 62, 9 200, 600, 1200, 3000 and 9400 Mc/s. The first of th above noise-bursts was observed on 62, 98 an 200 Mc/s, and the third on 62, 98, 200 and 600 Mc/ A burst was also observed $5\frac{1}{2}$ hr before the eruptio of the prominence. Ionospheric and magnetic dat showed no disturbances associated with the eruptio No noise-bursts were associated with two smalle eruptive prominences observed in 1952.

M. W. OVENDE

523.75 : 537.523

The 3000 Mc ion plasma noise radiated from ar discharge and solar eruption. *See Abstr.* 484

523.75

25. The effect of interstellar polarization in the sola corona. G. THIESSEN. *Z. Astrophys.*, **32,** *No.* 173–84 (1953) *In German.*

Qualitative proof of the existence of a polarizatio phenomenon in the Fraunhofer lines of the sol corona. This effect is considered as due to a part preferential orientation in space of elongated du particles, in analogy to the interstellar polarizatio It depends on the question as to whether we have deal with a magnetic mechanism according to Da and Greenstein, or to Spitzer and Tuckey, or with purely mechanical process as suggested by Gol Öhman's observations favour the reality of such polarization effect which follows the Davis–Gree stein type of paramagnetic absorption. This wou independently establish the existence of a gene magnetic field in the outer regions of the su the scarcity of the present observational data emphasized. A. BE

523

26. The apsidal motion and radius of gyration the proton-proton solar model. L. MOTZ. *Astroph J.*, **118,** 147–50 (*July*, 1953).

The apsidal motion constant, k, and the radius gyration, H/R, are calculated for the recently in grated proton-proton model of the sun. It is fo that the apsidal-motion constant gives a value of effective polytropic index which is smaller than is led to expect from observational data. The va of the radius of gyration obtained places the mo off the straight line that was previously found to e between $-\log k$ and $-\log H/R$ for main-seque stellar models.

52

27. Lyman-alpha radiation in the solar spectr E. T. BYRAM, T. CHUBB, H. FRIEDMAN AND GAILAR. Letter in *Phys. Rev.*, **91,** 1278 (*Sept* 1953).

The intensity of the Lyman-alpha line of hydro at 1216 Å, was measured with photon counters fl in 3 Aerobee rockets at the White Sands Pro

Grounds in New Mexico during May 1952. Plots of the continuous telemetered records of intensity against altitude, up to 128 km, were studied. During all these flights the line was first discovered at 74 km. The intensity variation with residual air path lead to an absorption coefficient of $0{\cdot}046\,cm^{-1}$, which compares well with laboratory measurements. The conversion of the counting rate of the photon counters into flux of incident energy was obtained by comparison with the response of special photomultiplier tubes, which were in turn compared with a calibrated mercury lamp; this calibration was checked satisfactorily after recovery of an undamaged counter. The measured solar intensity was $0{\cdot}10 \pm 0{\cdot}02$ ergs $cm^{-2}\,sec^{-1}$ at the top of the atmosphere [Tousey *et al.* gave 0·4, Abstr. 9209 (1951); Pietenpol *et al.* quoted 0·3, Abstr. 4567 (1953)]. Since it is known that within one ångström unit on either side of Lyman-alpha the absorption coefficient increases rapidly, and since here the measured absorption was found to be constant over the entire altitude range of the rocket, it is concluded that the width of the solar emission line must certainly be less than 1 Å. A further result is that the continuous solar emission background near 1200 Å was less than 0·01 erg $cm^{-2}\,sec^{-1}$ per 100 Å; this is equivalent to a blackbody temperature of less than 4600°K. It is also pointed out that although the new rocket data have been explained by attributing all the absorption to O_2, they do not exclude the possibility of the suggested production of the *D*-layer through absorption of Lyman-alpha by NO. A. BEER

523.77

28. Infrared multiplets and the solar spectrum. C. E. MOORE. *J. Opt. Soc. Amer.*, **43,** 1014–19 (*Nov.*, 1953).

The identification of solar lines in the photographic infrared region is discussed. Sample multiplets of C I, N I, O I, Na I, Al I, Si I, Ti I, and Fe I are listed to illustrate the consistency of term intervals within multiplets, when solar wave numbers are substituted for laboratory values. These data furnish an excellent criterion of both the precision of the solar data and the correctness of the assigned identifications. Solar lines produced by more than one contributor, i.e. blends, can be detected by irregularities in the solar term intervals within multiplets. A.

523.77 : 535.343.4–15

29. The ozone band near 4·7 μ in the solar spectrum. J. H. SHAW AND J. N. HOWARD. Note in *Astrophys. J.*, **117,** 460–1 (*May*, 1953).

Many previously unreported weak lines, obviously telluric, showed an envelope contour resembling the 2108 cm^{-1} ozone band. Lab. spectra of this band on a grating spectrometer gave convincing evidence in support of this identification. D. L. EDWARDS

523.821

30. Effect of spectral class on daylight visibility of stars. A. G. SMITH. Letter in *J. Opt. Soc. Amer.*, **43,** 806 (*Sept.*, 1953).

Contrary to expectation, tests of three separate pairs of stars of nearly equal magnitude, one of which was a *B*-star and the other a *K*-star, showed no apparent difference in visibility when observed with a low-power telescope in the daytime sky. Similarly, red or orange filters proved of little advantage. Colour contrast has little influence, therefore, in the detection of stars in daylight. D. R. BARBER

523.83 : 523.161

31. The possible influence of interstellar clouds on stellar velocities. II. L. SPITZER, JR, AND M. SCHWARZSCHILD. *Astrophys. J.*, **118,** 106–12 (*July*, 1953).

For previous part, see Abstr. 3230 (1952). The increase with time of random stellar velocities, as a result of gravitational encounters with interstellar cloud complexes, has been recomputed, taking into account the presence of differential galactic rotation. As a result of such non-uniform rotation, the clouds will have velocities relative to one another even if their random velocities are zero; the gravitational potential of these clouds will be a fluctuating function of time; and the stars will gain kinetic energy from the clouds. To explain the increase of velocity dispersion with advancing spectral type along the main sequence, the mass of a typical cloud complex must be in the neighbourhood of $10^6 m_\odot$, the value found previously; but the random velocity of a cloud complex, as a whole, is irrelevant and may be vanishingly small. Since inhomogeneities of density with the required scale of some 300 parsecs or more seem indicated by the extinction observations, it seems not unlikely that star-cloud encounters are, in fact, responsible for the greater velocity dispersion of the later-type, older stars of population type I. A.

523.851.3

32. An expansion effect in Hertzsprung's Pleiades catalogue. W. DIECKVOSS. Note in *Naturwissenschaften*, **40,** *No.* 19, 505 (1953) *In German.*

An expansion coefficient is determined from a study of proper motions and the age of the cluster is estimated to be $>2{\cdot}5\times10^6$ years. R. A. NEWING

523.854.1

33. Magnetic fields in spiral arms. S. CHANDRASEKHAR AND E. FERMI. *Astrophys. J.*, **118,** 113–15 (*July*, 1953).

Two independent methods are described for estimating the magnetic field in the spiral arm in which we are located. The first method is based on an interpretation of the dispersion (of the order of 10°) in the observed planes of polarization of the light of the distant stars; it leads to an estimate of $H = 7{\cdot}2\times10^{-6}$ gauss. The second method is based on the requirement of equilibrium of the spiral arm with respect to lateral expansion and contraction: it leads to an estimate of $H = 6\times10^{-6}$ gauss. A.

523.87

34. Measures of the Paschen discontinuities [in stellar spectra]. M. BLOCH AND M.-L. TCHENG. *C.R. Acad. Sci* [*Paris*] **237,** 782–4 (*Oct.* 12, 1953) *In French.*

Preliminary results for a number of bright stars, from differential measures (taken in pairs) calibrated by a tungsten lamp comparison spectrum, yield mean values of the Paschen discontinuity for spectral types *B3–G0*. The mean ratio of Paschen to Balmer discontinuities for these types is about 1/3.

D. L. EDWARDS

523.872

35. Intercomparison of shell spectra. P. W. MERRILL AND A. L. LOWEN. *Astrophys. J.*, **118,** 18–26 (*July*, 1953).

Estimates of the intensities of lines of the following elements are recorded for 21 shell stars and 2 c stars; H ($m = 6$ and $m = 30$), Mg I, Ca II, Sc II, Ti II, Cr II, Fe II, Ni II. Correlation plots show that lines of Mg I, Ti II and Cr II behave about alike. Lines of Sc II and Ni II show an inverse correlation, although with much scatter; neither element shows a close correlation with other elements. Atomic data offer a partial explanation of these facts. Photometric measurements on the diffuse line λ4026 He I are recorded for 9 stars. The central absorption ranges from 3 to 12%; the actual width, from 5 to 12 Å. Data concerning motions in shells are summarized. In most shells the velocity varies slowly through a large range, and the line structure shows small changes during the velocity-cycle, wings appearing on the side toward which the lines are moving. In stable shells the lines are symmetrical and sharp. Atoms that form a shell probably leave the photosphere very slowly; sometimes they are subject to an outward acceleration. The nature of the outward force is briefly discussed. A.

523.872 : 523.841.11

36. The red coronal line in the spectra of novae. D. B. MCLAUGHLIN. *Astrophys. J.*, **118,** 27–34 (*July*, 1953).

A systematic search was made for coronal lines, which have been strong in the spectra of some recurrent novae. The green line, λ5303 [Fe XIV], was neither identified nor suspected in any of the spectra examined. The emission band about λ6364, commonly attributed chiefly to [O I], was composite in the spectra of several novae. Measurements of edges and maxima revealed features that find no satisfactory identification other than λ6374 [Fe X]. The line emerged nearly concurrently with the nebular lines of [O III] and reached maximum strength a few months after light-maximum. The identification is considered certain in Nova CP Puppis 1942 and Nova Aquilae 1918: very probable in CP Lacertae 1936 and Nova Geminorum 1912; uncertain in three others. A.

523.877

37. Problems of gravitational stability in the presence of a magnetic field. S. CHANDRASEKHAR AND E. FERMI. *Astrophys. J.*, **118,** 116–41 (*July*, 1953).

A number of problems are considered which are related to the gravitational stability of cosmical masses of infinite electrical conductivity in which there is a prevalent magnetic field. In Section I the virial theorem is extended to include the magnetic terms in the equations of motion, and it is shown that when the magnetic energy exceeds the numerical value of the gravitational potential energy, the configuration becomes dynamically unstable. It is suggested that the relatively long periods of the magnetic variables may be due to the magnetic energy of these stars approaching the limit set by the virial theorem. In Section II the adiabatic radial pulsations of an infinite cylinder along the axis of which a magnetic field is acting is considered. An explicit expression for period is obtained. Section III is devoted to investigation of the stability for transverse oscillati of an infinite cylinder of incompressible fluid wh there is a uniform magnetic field acting in the direct of the axis. It is shown that the cylinder is unsta for all periodic deformations of the boundary w wavelengths exceeding a certain critical val depending on the strength of the field. The wa length of maximum instability is also determined. is found that the magnetic field has a stabilizing eff both in increasing the wavelength of maximu instability and in prolonging the time needed for instability to manifest itself. For a cylinder of rad $R = 250$ parsec and $\rho = 2\times10^{-26}$ g/cm^3 a magne field in excess of 7×10^{-6} gauss effectively removes instability. In Section IV it is shown that a fi sphere with a uniform magnetic field inside and dipole field outside is not a configuration of equ brium and that it will tend to become oblate contracting in the direction of the field. Finally, Section V the gravitational instability of an infi homogeneous medium in the presence of a magne field is considered, and it is shown that Jea condition is unaffected by the presence of the field.

523.

38. The influence of a magnetic field on the [re tional] stability of stars. E. TANDBERG-HANSS *Ann. Astrophys.*, **16,** *No.* 4, 206–16 (1953) *In Fren*

A mathematical study of the interaction betwee stellar magnetic field and the internal current sys set up by the star's rotation. It is shown fo different models that the resultant electromagn forces influence the form of the star; and equati are derived from which the surface perturbations be found. D. R. BAH

523

39. The role of dusts in the atmospheres of the stars. P. SWINGS. Note in *Ann. Astrophys.*, *No.* 4, 287 (1953) *In French.*

It seems probable that the continuous absorp present in the photographic region of the spectru *N*-type stars is indicative of scattering by ca (smoke) particles in the outer layers of the st atmosphere. Certain of these "carbon" stars s pronounced magnitude changes which may explained by fluctuations of the depth of the dust-layer. A somewhat similar veiling of the continuum of the spectrum of more-advanced ty stars is attributed to metallic-oxide dusts.

D. R. BA

523.877 : 5

40. The effect of electron screening on the nuclear energy generation. G. KELLER. *Astroph* **118,** 142–6 (*July*, 1953).

It is known that thermonuclear reaction rate sensitive to the heights of the intra-nuclear pot barriers. Since the height of a barrier will be re by the presence of screening electrons, computa have been made to determine the corresponding on the reaction rate of the carbon cycle. It has found that, under conditions typical of the inter the sun, the reaction rate should be increased factor of 1·54. Under conditions representat

red dwarf interior, the increase is by a factor of or more. Neither factor is likely to be important n the theory of stellar structures unless it should turn ut that the proton-proton reaction is inoperative. A.

525.35 : 531.382

1. On the dynamical theory of the rotation of the arth. II. The effect of precession on the motion of the iquid core. H. BONDI AND R. A. LYTTLETON. *Proc. Cambridge Phil. Soc.*, **49**, *Pt* 3, 498–515 (1953).

A continuation of previous work [Abstr. 2314 1948)]. The effects of precession and mutation are ow considered. The equations of steady motion applicable to the interior, and those applicable to the boundary layer are obtained. The latter are solved; but for the former it has only been possible to show that no motion representable everywhere by analytic functions is possible. This suggests that no steady-state motion is possible for the interior. It is concluded that the principal result of the precessional motion of the earth is to impose a motion on the fluid interior that cannot remain permanently steady (unless the viscosity is very high), and that it departs from steady motion, at least from time to time, by the onset of turbulence near the surface of the core, and in latitudes 30° N and 30° S. L. S. GODDARD

PHYSICS 53

53 : 37

42. Some thoughts on the educational process. E. HUTCHISSON. *Amer. J. Phys.*, **21**, 532–6 (*Oct.*, 1953).

Analyses the educational process, using graphical methods wherever possible. In its simplest aspect education is represented by a growth curve. If restricted to a single subject the curve is a two-dimensional one and may include both learning and forgetting. The mechanism of learning appears to be quite different for accumulative subject matter such as mathematics or physics from that in non-accumulative fields such as political theory or business management. Combining the learning curves for several subjects one obtains an educational pattern which may be directly related to particular job requirements or to college admission requirements. A.

53 : 621.317.2

43. Electrical equipment for physics lecture demonstrations. W. G. WADEY. *Amer. J. Phys.*, **21**, 503–9 (*Oct.*, 1953).

A revision and rebuilding of the general-physics lecture apparatus used at Yale for electronic and electrical demonstrations has resulted in a set of pieces of apparatus designed to minimize the time wasted by the lecturer in wiring and arranging equipment. At the same time the students have a clearer view of the essentials. Improvements and modifications may be made economically. Brief descriptions of the use of the apparatus are included. A.

53.08 : 519.24

44. Rejection of outlying observations. F. PROSCHAN. *Amer. J. Phys.*, **21**, 520–5 (*Oct.*, 1953).

Makes available to the physicist two of the modern statistical tests for possible rejection of outlying observations. These two methods have been selected because they apply in a majority of the actually occurring situations and because they are so easy to use. A.

FUNDAMENTALS 530.1

530.12

45. On equivalent observers. Y. UENO AND H. TAKENO. *Progr. theor. Phys.*, **8**, 291–301 (*Sept.*, 1952).

The nature of equivalent observers (hereafter to be designated as E.O.) is investigated. As a result it is found that a new idea of E.O. must be introduced different from the E.O. hitherto employed to treat various phenomena in physics. The existence of two kinds of E.O. in the sense here employed is shown and their properties briefly studied. A.

530.12

46. On the spherically symmetric space-times in general relativity. H. TAKENO. *Progr. theor. Phys.*, **8**, 317–26 (*Sept.*, 1952).

Spherically symmetric space-times play important roles in general relativity. In this note a theory is developed concerning the problem of determining whether or not a space-time defined by a line element arbitrarily given in any co-ordinate system is spherically symmetric, using the concept of characteristic system introduced by the present author (1951). Then, as an example, the theory is applied to the space-times of Weyl and Levi-Civita, of Gödel and of Silberstein. A.

530.12

47. A generalization of the Gauss theorem. M. LENOIR. *C.R. Acad. Sci.* [*Paris*], **237**, 384–5 (*Aug.* 5, 1953) *In French.*

The flux theorem is generalized to the case of a non-symmetric metric tensor. R. A. NEWING

530.12

48. Regularity theorem in Einstein's latest theory. M. LENOIR. *C.R. Acad. Sci.* [*Paris*] **237**, 424–5 (*Aug.* 10, 1953) *In French.*

A theorem due to A. Lichnerowicz states that a stationary space-time which is everywhere regular is Euclidean. This theorem is shown to be invalid in the case of a non-symmetric metric tensor.

R. A. NEWING

530.12

49. The theory of finite displacement operators and fundamental length. B. T. DARLING AND P. R. ZILSEL. *Phys. Rev.*, **91**, 1252–6 (*Sept.* 1, 1953).

The general finite displacement operator in an n-dimensional complex continuum is defined as an arbitrary superposition of exponential Taylor operators (a Taylor operator yields a Taylor's series). On restriction to the space-time continuum and four-dimensional time-like intervals of constant length ω, the corresponding finite displacement operator may be considered as an ordinary function of the operators u_σ (the partial derivative with respect to x_σ), and must satisfy a Klein–Gordon type equation in u space.

This equation possesses relativistic invariant and four-vector solutions that in the limit $\omega \to 0$ reduce to 1 and u_σ, respectively. These operators are combined with the Compton wavelength k and the Dirac or Duffin γ_σ, respectively, to produce a relativistically invariant correspondence type finite-displacement operator generalization of the Dirac–Duffin equation. If the fields are charged, the electromagnetic potentials may be introduced in a manner which leaves the mass spectrum unaltered. The relationship to other non-local theories and to the reciprocity theory of Born is briefly considered. A.

530.12 : 536.7

50. The Cauchy problem for a perfect thermodynamic fluid. PHAM MAN QUAN. *C.R. Acad. Sci. [Paris]* **237,** 22–4 (*July* 6, 1953) *In French.*

Continuation of previous work [Abstr. 7422 (1953)]. R. A. NEWING

530.12 : 538.11

51. Affine field structure of gravitation and electromagnetism. G. STEPHENSON. Letter in *Nuovo Cimento*, **10,** 354–5 (*March*, 1953).

The introduction of a non-symmetric affine connection [Abstr. 8209 (1953)] is shown to be unsatisfactory since the resulting electromagnetic equations show no resemblance to Maxwell's equations. G. FIELD

530.145

52. The logical foundations of quantum mechanics. H. REICHENBACH. *Ann. Inst. Poincaré*, **13,** *No.* 2, 109–58 (1953) *In French.*

Some fundamental concepts in classical and quantum theory are discussed under four chapter headings: indetermination; unobservables and three valued logic; the direction of time in classical physics; the direction of time in quantum physics. P. M. DAVIDSON

530.145

53. On the Hamiltonian structure of non-local field theories. W. PAULI. *Nuovo Cimento*, **10,** 648–67 (*May*, 1953).

For the example of the Kristensen–Möller theory expressions are given for energy, momentum and charge which are constant in the course of time as a consequence of the field equations. For the case where the fields are classical and that the manifold of solutions is the same as for free fields (normal class), canonical field variables fulfilling the Hamiltonian formalism are proved to exist. In the first order approximation of the perturbation theory the canonical field variables are actually constructed also for quantized fields. A.

530.145

54. Properties of form factors in non-local theories. M. CHRÉTIEN AND R. E. PEIERLS. *Nuovo Cimento*, **10,** 668–76 (*May*, 1953).

The conditions for absence of non-causal actions over large time intervals in non-local theories are expressed as conditions on the Fourier transform of the form function. A.

530.145

55. A quantum theory of boson assemblies. I. T. NISHIYAMA. *Progr. theor. Phys.*, **8,** 655–68 (*Dec.*, 1952).

The temporal evolution of boson assemblies is studied. The equations of the density matrix and the phase space distribution function are given in scheme of second quantization. The velocity opera is introduced, and its algebraic properties are examin and it is intended that the conventional quant mechanics be reformulated in terms of the amplit operator $R(x)$ and the velocity operator $v(x)$. Hamiltonian of the system is expressed in terms these two operators apart from surface effects.

530

56. Relativistic field quantization. B. M. GAONKAR. *Proc. Indian Acad. Sci. A,* **36,** 482 (*Dec.*, 1952).

A method is given for quantizing any relativ wave equation for a particle of arbitrary spin non-zero finite values of the rest-mass, which ca written in the canonical form $(\alpha^k p_k + \chi)\psi = 0$. general commutation rule of the ψ and ψ is g in every case. A necessary and sufficient cond to be satisfied by the α's in order that the cha density and the energy density be non-zero has deduced and is that the minimal equation of α^0 sh not have repeated factors other than α^0 itself.

530

57. The construction of potentials in quantum theory. A. KLEIN. Letter in *Phys. Rev.*, **91,** (*Sept.* 1, 1953).

A method of successive elimination of the vector components from the Schrödinger equati described, which leads to the same result as Bruec and Watson's method [Abstr. 4616 (1953)]. It be applied to linear and non-linear meson cou with or without nucleon pair production. G.

536

58. A new attempt on the self-energy problem o photon. O. HARA AND H. SHIMAZU. *Progr. t Phys.*, **8,** 265–79 (*Sept.*, 1952).

The self-energy problem of the photon is in gated using an idea of renormalizing the light vel It is shown that the self-energy ΔE and the alter of the light velocity due to the interaction Δ connected by the relation $E + \Delta E = p(c +$ where E, p and c are the energy, the momentum the velocity of a free photon respectively. normalizing c on the ground of this relation, a t of the interaction of the electromagnetic and ele fields is given in a form which is invariant Lorentz and a gauge transformation, and is free the divergence of the self-energy of the photo description of the Lagrangian formalism of the t follows. Calculations in this paper are restrict the e^2 approximation.

53

59. Nonlinear electrodynamics and elementary J. PLEBAŃSKI. *Bull. Acad. Polon. Sci. Cl.* 3, **1,** *No* 34–8 (1953).

Assumptions in addition to those of gau variance and relativistic covariance are need obtain an unambiguous Lagrangian in non- electrodynamics. Taking as a starting po spherically symmetrical scalar potential ϕ, it be possible to determine the Lagrangian, or "elementary law" $\partial\phi/\partial r = p(r)$ could be Possible forms of $p(r)$ are investigated which give physically acceptable results. G.

530.145

60. Some aspects of the problem of measurability in quantum electrodynamics. E. CORINALDESI. *Nuovo Cimento*, **10** (*Suppl. No.* 2) 83–100 (1953).

Account of the viewpoints of the papers by Landau and Peierls and by Bohr and Rosenfeld, and of some relevant commutators and anticommutators for the case of interaction with electrons and with scalar mesons. [See also Abstr. 9267 (1951); 4126 (1952)].

W. A. HEPNER

530.145

61. A pre-renormalized quantum electrodynamics. H. S. GREEN. *Proc. Phys. Soc.* [*London*] *A*, **66,** 873–80 (*Oct.*, 1953).

A pair of integral equations is derived, which, together with a well-defined mathematical procedure, will automatically generate the elements of the *S*-matrix in their accepted renormalized form. A.

530.145

62. On the structure of the interactions of the elementary particles. III. On the renormalizable field theory. S. KAMEFUCHI AND H. UMEZAWA. *Progr. theor. Phys.*, **8,** 579–98 (*Dec.*, 1952).

For Pt II, see Abstr. 2953 (1953). The theory is defined as an assembly of spin 0 and $\frac{1}{2}$ fields and neutral vector fields (including the electromagnetic field) interacting with each other via interactions of 1st kind only. It is shown that there are several rules of renormalization, which lead to not necessarily identical finite results, and the separation of divergences is discussed. The outline of the renormalization method is given and there one can see the equivalence of the "subtraction" and the "renormalization" methods. The gauge invariancy of the renormalized theory is examined and some comments are made on its present form. A.

530.145

63. An electrodynamical example of Van Hove's orthogonality theorem. A. LOINGER. Letter in *Nuovo Cimento*, **10,** 498–9 (*April*, 1953) *In Italian.*

See Abstr. 4125 (1952). It is shown that the Hilbert space of the stationary states of the field in interaction with its sources is orthogonal to the Hilbert space of the source-free field also in the case of an electron interacting with the e.m. field. The theorem is proved in the non-relativistic and dipole approximation, and neglecting the term containing the square of the vector potential. L. PINCHERLE

530.145

64. A covariant formulation of the non-adiabatic method for the relativistic two-body problem. I. M. CINI. *Nuovo Cimento*, **10,** 526–39 (*May*, 1953).

The non-adiabatic treatment of the relativistic two-body problem can be done with the Tamm–Dancoff method [*Journal of Physics* (*USSR*) **9,** 449 (1945); Abstr. 6264 (1950)], or with the Bethe–Salpeter equation [Abstr. 1469 (1952)]. The first one is formally non-covariant, and no radiative effects can be computed; the latter is covariant, but the physical interpretation of the "wave function" involved is not clear. In the present paper a covariant formulation of the Tamm–Dancoff method is found, with the purpose of performing the renormalization of the divergent terms, thus obtaining a consistent and unambiguous field-theoretical treatment of the two-body bound state. An integral equation up to fourth order terms in powers of the coupling constant is given for the representative of the state vector in the interaction representation describing two nucleons at different space-time points. In Pt II the renormalization procedure of such equation will be discussed. A.

530.145

65. A covariant formulation of the non-adiabatic method for the relativistic two-body problem. II. M. CINI. *Nuovo Cimento*. **10,** 614–29 (*May*, 1953).

It has been shown in Pt I how the Tamm–Dancoff non-adiabatic treatment of the relativistic problem of two particles interacting through a neutral pseudoscalar meson field can be put in a covariant form. The integral equations obtained involve infinite kernels corresponding to radiative processes. In the present part, the techniques of Dyson and Matthews for the renormalization of the *S*-matrix have been applied in order to separate from the kernel of the integral equations a convergent part, showing that the divergent contributions can be absorbed in unobservable mass and coupling constant renormalization. If we assume the normalized masses and charge to be defined by the same formal series with divergent constant terms as in the *S*-matrix, as required if a physical meaning is to be attached to the renormalization procedure, finite contributions arise also from self-energy kernels of non-interacting particles. The terms arising from disconnected loops in the vacuum can be eliminated if the same approximation is used as in the *S*-matrix theory, namely that the time dependence of the state vector can be neglected in these integrals. A.

530.145

66. Mass-renormalization with the Tamm–Dancoff method. F. J. DYSON. Letter in *Phys. Rev.*, **91,** 421 (*July* 15, 1953).

For the "new Tamm–Dancoff method" [Abstr. 5854 (1953)] the divergence problem connected with the self-energy of a single particle is discussed and a non-covariant prescription for its renormalization is proposed. The covariant Cini renormalization method [see previous abstract] is examined and shown to be ambiguous in the old T–D method, but to agree with this non-covariant prescription in the new T–D method. R. H. DALITZ

530.145

67. Note on the structure of the interactions between unstable elementary particles. S. ÔNEDA. Letter in *Progr. theor. Phys.*, **8,** 255–6 (*Aug.*, 1953).

General conservation laws, especially conservation of nucleons, are applied. G. E. BROWN

530.145

68. Directional correlations for simultaneous two-quanta processes. W. KRÓLIKOWSKI. *Bull. Acad. Polon. Sci. Cl.* 3, **1,** *No.* 1–2, 27–33 (1953).

The case of a nucleus interacting with a radiation field is taken and correlation formulae for the directions of two photons are given. The formulae apply to photons of electric dipole type. G. FIELD

530.145

69. Explicit matrix elements for multipole radiation. P. B. TREACY. *Austral. J. Phys.*, **6**, 241–4 (*Sept.*, 1953).

Using a simple model, a formula is given for the radiation intensity from a multipole of any order. This formula is extended to include polarization properties of quanta. As an example, a matrix element is calculated for multipole radiation of order four. A.

530.145

70. Deficiency of the phenomenological theory of the Lamb shift. F. J. BELINFANTE. Letter in *Phys. Rev.*, **91**, 1284 (*Sept.* 1, 1953).

The theory [Abstr. 1454 (1952)] is unable to account for the extra term $(-2\ln Z)\delta_{l,0}(8Z^4\alpha^3 Ry/3\pi n^3)$ in the correct quantum electrodynamical formula for the Lamb shift δE_{nlj} which is in agreement with the experimental result for He^+. G. FIELD

530.145

71. Interaction between classical electron and quantized electromagnetic field. I. R. SENITZKY. *Phys. Rev.*, **91**, 1309–11 (*Sept.* 15, 1953).

The equations of motion for a quantized electromagnetic field subject to the influence of a classical electron of arbitrarily prescribed velocity are solved by a simple method involving the corresponding difference equations. The solution yields some results which are contrary to those of an earlier theory. An expression for the transition probabilities between a high energy state and neighbouring states of the field inside a resonant cavity is obtained. A.

530.145

72. The change in our conception of the elementary particles. W. FINKELNBURG. *Naturwissenschaften*, **40**, *No.* 17, 445–9 (1953) *In German.*

A discussion of the development of the past 20 years and of the significance of fundamental particles for the future of physics. Examples of classical electron models are given, especially Hönl's mass dipole model (1952). W. J. SWIATECKI

530.145

73. Isotopic spin of nucleons and leptons and antiparticle coordinate. T. HAMADA AND M. SUGAWARA. Letter in *Progr. theor. Phys.*, **8**, 256–8 (*Aug.*, 1952).

If electrons and neutrinos have isotopic spin projections $+\frac{1}{2}$ and $-\frac{1}{2}$, respectively, then positrons and anti-neutrinos have projections $-\frac{1}{2}$ and $+\frac{1}{2}$, respectively. G. E. BROWN

530.145

74. On the use of an approximation method in Dirac's electrodynamics. L. INFELD. *Bull. Acad. Polon. Sci. Cl.* 3, **1**, *No.* 1–2, 18–22 (1953).

An approximation method, which has previously been used in the cases of motion of bodies in gravitational, electromagnetic, and nuclear fields [Abstr. 7048 (1952)], is applied to the new non-linear electrodynamic field equations of Dirac. The four-vector potential is developed with respect to the parameter $1/c$ (c = vel. of light), so that the time derivative of the nth order term is of order $(n+1)$. The solution of the field equations is found to any required order of approximation. G. FIELD

530.145

75. A new approximation method for the meson field theory. J. WERLE. *Bull. Acad. Polon. Sci. Cl.* 3, **1**, *No.* 1–2, 23–6 (1953).

The method of the preceding abstract is applied to the general equation of type $(\Box - \mu^2)\phi(x,t) = -4\pi\Omega\delta(x-x')$, where Ω is the operator characterizing the field sources and is assumed to commute with the Laplacian operator. ϕ is expanded in even orders of time derivatives. No term of the expansion will then contain a singularity higher than that of the first term. The expansion is invariant under time reversal when Ω contains no time differentiations. G. FIELD

530.145

76. Retardation of meson fields. H. OLSEN, P. WERENSKIOLD AND H. WERGELAND. *K. Norske Vidensk. Selsk. Forhandl.*, **25**, *No.* 14, 56–9 (1952).

An integral representation of a scalar meson field arising from a point nucleon source is given. The integral can be carried out and the meson field expressed explicitly only in special cases. In general, it is not possible to relate the field to the state of motion of the source at a single retarded point, as in electrodynamics, because the meson interactions are not confined to the surface, but extend to the whole interior of the past light cone. G. E. BROWN

530.145

77. Pion reactions in one nucleon system and nucleon isobars. S. MINAMI, T. NAKANO, K. NISHIJIMA, H. OKONOGI AND E. YAMADA. *Progr. theor. Phys.*, **8**, 531–48 (*Nov.*, 1952).

Attempts to interpret the pion-nucleon interaction on the basis of the nucleon isobar model. As a method complementary to strong coupling and phenomenological theories, the field theoretical viewpoint is adopted and will be useful to connect the present phenomenological theory of pions to the future theory of fields. Nucleon isobars are treated as elementary particles and described by Rarita–Schwinger equation of particles with spin 3/2. Hence the familiar Feynman–Dyson method is immediately applicable to the calculation of matrix elements of such processes involving nucleon isobars as pion-proton scattering and pion production by γ-rays on protons. The qualitative features are governed mainly by the mass, width, spin and isotopic spin of the isobar, so that results roughly agree with those of the strong coupling and phenomenological theories. In some detailed respects, however, the results show differences from other theories; agreement with experiments is improved for the angular distributions of $\pi - p$ scattering and photoproduction of charged pions, but becomes a little worse for that of neutral pions. The method is applied only to pion reactions in a one-nucleon system, for too little is known about two or more nucleon systems to extract the pure pion-nucleon interaction. Lastly, the validity of nucleon isobars is discussed. A.

530.145

78. On the convergence of the *S*-matrix series. S. HORI. Letter in *Progr. theor. Phys.*, **8**, 569–70 (*Nov.*, 1952).

The coefficient of the nth term in the S-matrix series increases as $2^n n!$ Some of the graphs in the

nth term give zero contribution, but the series still diverges. G. E. BROWN

530.145

79. The Fredholm theory of the S matrix. J. HAMILTON. *Phys. Rev.*, **91**, 1524–6 (*Sept.* 15, 1953).

The equation for the interaction representation transformation operator is put into integral form and the Fredholm theory of integral equations is used to give an explicit expression for the solution. No extension of the circle of convergence of the S matrix seems possible in the general case. A.

530.145

80. On the equivalence of the particle formalism and the wave formalism of meson. Z. TOKUOKA AND H. TANAKA. *Progr. theor. Phys.*, **8**, 599–614 (*Dec.*, 1952).

Dyson–Feynman's S-matrix for the meson-photon dynamical system in the β-formalism is shown to be equivalent to that in the wave formalism, explicitly. The Fujiwara's β-matrix formulation is used. The bilinear terms in the electromagnetic field are discarded with use of the modified propagation function of meson and so the Feynman diagrams in the β-formalism consist only of 3-vertices. On the other hand, the diagrams in the wave formalism consist of 4-vertices as well as 3-vertices. In spite of this apparent difference of both formalisms, the equivalence is complete. A.

530.145

81. On the three-body potential. M. JEAN AND J. RATIER. *C.R. Acad. Sci.* [*Paris*] **237**, 305–7 (*July* 27, 1953) *In French.*

The potential is deduced from the S-matrix for charge-symmetric pseudoscalar theory with pseudoscalar coupling. The lowest order contributions (fourth and sixth in the coupling constant) are given and their relative importance discussed. G. FIELD

530.145

82. Complementarity in angular-momentum states. B. A. LIPPMANN. *Phys. Rev.*, **91**, 1213–15 (*Sept.* 1, 1953).

By introducing operator representations for angular-momentum states referred to arbitrary axes of quantization, two independent angular momenta, each referred to its own axis of quantization, may be combined quantum-mechanically. An interpretation in terms of complementarity shows that this method of adding angular momenta corresponds to a "causal" description, while the usual method (using only one axis of quantization) is a "geometric" or space-time description. "Causal" angular-momentum states automatically avoid the sums over magnetic quantum numbers in cascade processes. A.

530.145

83. The number of Feynman diagrams. R. J. RIDDELL, JR. *Phys. Rev.*, **91**, 1243–8 (*Sept.* 1, 1953).

The Feynman–Dyson formulation of a perturbation expansion for quantum field theory allows a general combinatorial treatment to the Feynman diagrams involved. A very simple analysis for the total number of such diagrams, $T(n, \varepsilon, \rho)$, in quantum electrodynamics, leads to:

$$T(n, \varepsilon, \rho) = \frac{(n!)^2}{(\varepsilon!)^2(n-\varepsilon)!} \cdot \frac{n!}{\rho![\frac{1}{2}(n-\rho)]!2^{\frac{1}{2}(n-\rho)}},$$

in which n is the order of the perturbation and ε, ρ are the number of external electron and photon lines, respectively. The first factor is the number of different diagrams using only the electron lines and the second is that for the photon lines. In this total set of diagrams are many undesired ones; these are removed by means of generating functions. Relations which these functions satisfy are obtained, and from them one may readily find the exact numbers of diagrams desired, for not too large n. The generating functions are also used to find the asymptotic dependence on n, and it is found that this dependence is essentially unaffected by removing any specific type of graph. The sign alternations of the matrix elements in quantum electrodynamics are also considered in terms of similar generating functions. The generalization of the analysis to other types of interactions is also discussed. A.

530.145

84. S-matrix and causality condition. II. Non-relativistic particles. N. G. VAN KAMPEN. *Phys. Rev.*, **91**, 1267–76 (*Sept.* 1, 1953).

For Pt I, see Abstr. 2960 (1953). The application of the "causality condition" to the S-matrix for non-relativistic particles encounters several difficulties: (*a*) there is no maximum velocity; (*b*) the interference of ingoing and outgoing waves has to be taken into account; (*c*) wave packets with a sharp front do not exist. The condition is therefore reformulated as follows: At any time the total probability of finding the particle outside the scattering centre shall not be greater than 1, for every form of the incident wave packet. From this follows for spherical waves that S, as a function of the momentum p, is analytic and holomorphic in the first quadrant and that $e^{2iap}S(p)$ (where a is the radius of the scattering centre) has an imaginary part $\leqslant 1$. That suffices to give an explicit integral representation and a product expansion for S, but these permit a more general form for S than is usually envisaged. If, however, the usual symmetry relation $S(-p) = S(p)^*$ is assumed in addition to the causality condition, more specific equations can be derived, which are direct generalizations of those in Pt I. In particular, integral relations between the real and imaginary parts of S, and the properties that Wigner found for the R matrix can be deduced. A.

530.145

85. Properties of the Salpeter–Bethe two-nucleon equation. J. S. GOLDSTEIN. *Phys. Rev.*, **91**, 1516–23 (*Sept.* 15, 1953).

The relativistic two-nucleon equation of Salpeter and Bethe is examined in the ladder approximation for large binding energy, with an invariant interaction function. The binding energy is considered an adjustable parameter and the coupling constant, $g^2/4\pi$, is taken as the eigenvalue of the problem. As a starting point for this study, the special case of two equal masses and binding energy equal to the total mass is considered. It is found that in this case the equation may be simplified to a remarkable degree. For zero quantum mass, a one-dimensional integral equation in momentum space is obtained, and solved, in closed form. The solutions can also be displayed in closed form in configuration space. Solutions exist corre-

sponding to this binding energy for all positive g^2. Requiring normalizability on a space-like surface in configuration space eliminates solutions for sufficiently small g^2, but a normalizable continuum remains. Arguments are presented to show that this continuum is not due to the choice of binding energy, but is, in fact, characteristic of the invariant equation. It is shown that by introducing a h.f. cutoff into the particle propagators and then going to the limit of infinite cutoff, the remaining continuum is reduced to a single physically sensible solution. A.

530.145

86. Many-body forces and nuclear saturation. S. D. DRELL AND K. HUANG. *Phys. Rev.*, **91**, 1527–42 (*Sept.* 15, 1953).

Nuclear saturation is studied with many-body interactions derived from pseudoscalar meson theory with pseudoscalar coupling. All parameters appearing in this calculation are fixed on the basis of the work of Lévy, who has shown that leading terms in a perturbation deduction of the two-body interaction are well fitted to reproduce the experimental data. The leading term in the n-body potential depends only on the interparticle distances and is repulsive (attractive) for n odd (even). The energy of the nucleus is calculated with potentials up through five-body interactions and with neglect of Coulomb and surface effects. Saturation properties derived from these considerations are in accord with experience. Antisymmetrization of the nuclear wave function reduces the many-body interaction energies considerably by inhibiting the close approach of many particles. Thus the Pauli exchange terms are found to reduce the five-body interaction energy by 76% and to give a rapid convergence for the expansion in n-body forces. A.

530.145

87. Many-nucleon forces. G. WENTZEL. Letter in *Phys. Rev.*, **91**, 1573 (*Sept.* 15, 1953).

The n-body nuclear potential is calculated on the basis of scalar meson pair theory, in the non-relativistic limit with a cut-off at large momentum.

P. T. MATTHEWS

530.145

88. A comparison of various methods of solving the central force scattering problem. J. S. TURNER AND R. E. B. MAKINSON. *Proc. Phys. Soc.* [*London*] *A*, **66**, 866–72 (*Oct.*, 1953).

The variational methods employed by several writers are discussed, and their methods of choosing parameters in a trial wave function examined. It is pointed out that the parameters may be obtained in other ways, while still using the variation principle to compute an improved value of the asymptotic phase. The essentially equivalent process of perturbing a simple potential into the given form and evaluating the first order perturbation is also considered. The advantages and limitations of several methods proposed are examined numerically in a particular case of scattering by a Yukawa potential. A.

530.145

89. Scattering theory—a second note. D. PARK. *Amer. J. Phys.*, **21**, 540–1 (*Oct.*, 1953).

Continues an earlier paper [Abstr. 5543 (1952)], and gives a general symbolic solution of equations of the type of the Schrödinger equation with sources. From this it is easy to see the connection which exists between the solutions of two important special problems: that in which the function vanishes initially and is therefore entirely determined by the source, and that in which the source vanishes and the function is entirely determined by its value at some initial instant. A.

530.145

90. Note on the perturbation calculation of phase shifts for central and non-central interactions. A. B. BHATIA AND K. HUANG. *Proc. Indian Acad. Sci. A*, **35**, 14–18 (*Jan.*, 1952).

It is shown that the calculation of the phase shifts can be reduced to an ordinary eigen-value problem (for a closed state). By applying the usual perturbation theory to the latter, the phase shifts are readily obtained as series in powers of the interaction potential. The procedure, it is shown, is applicable to non-central as well as centrally symmetric interactions. Explicit expressions for phase shifts up to second order are given for both kinds of potentials. A.

530.145

91. Analytical representation of spin. T. YAMAMOTO. Letter in *Progr. theor. Phys.*, **8**, 258–9 (*Aug.*, 1952).

The Pauli spin operators are expressed as differential operators, operating on eigenfunctions in two variables. G. E. BROWN

530.145

92. Generalization of analytical spin. T. YAMAMOTO. Letter in *Progr. theor. Phys.*, **8**, 570–1 (*Nov.*, 1952).

The expression of Pauli spin operators as differential operators operating on eigenfunctions involving two variables (preceding abstract) is generalized to the Dirac α's, which may be similarly expressed, in three variables. In general, a spin matrix of 2^n rows and columns can be expressed as a differential operator in $n + 1$ variables. G. E. BROWN

530.145

93. Phenomenological explanation of magnetic moments of nucleons in terms of the excited states of nucleons. M. SUGAWARA. *Progr. theor. Phys.*, **8**, 549–56 (*Nov.*, 1952).

The anomalous magnetic moment of nucleons is explained phenomenologically by inclusion of the virtual transition to excited state of $\sigma = 3/2$ and $\tau = 3/2$ accompanied by one meson emission in addition to the usual virtual transitions of nucleon states accompanied by meson emissions. The inclusion of excited state of $\sigma = 3/2$ and $\tau = 3/2$ is definitely essential and the inclusion of other excited states of $\sigma = 3/2$ and $\tau = 1/2$ or $\sigma = 1/2$ and $\tau = 3/2$ is of no effect. Six conclusions are obtained and discussed. A.

530.145

94. A generalization of the quantum mechanics. M. SCHÖNBERG. Letter in *Nuovo Cimento*, **10**, 350–3 (*March*, 1953).

It is pointed out that the Schrödinger equation satisfied by the linear functionals of the state vector with respect to a set of normalized functions in

Hilbert space admits also non-linear solutions. The inner product of two functionals is defined and the physical interpretation of the formalism is considered. W. A. HEPNER

530.145

95. Spin-orbit coupling in Riemannian spaces. J. GÉHÉNIAU AND C. LIESSE. *C.R. Acad. Sci.* [*Paris*] **237,** 303–4 (*July* 27, 1953) *In French.*

In spherically symmetrical Riemannian space, the energy eigenvalue equation for a spin-1/2 particle is shown to contain a spin-orbit coupling term even in the non-relativistic approximation. With proper choice of the metric, this may lead towards an explanation of strong spin-orbit coupling in nuclei. G. FIELD

530.145

96. On the causal and non-linear interpretation of wave mechanics. L. DE BROGLIE. *C.R. Acad. Sci.* [*Paris*] **237,** 441–4 (*Aug.* 17, 1953) *In French.*

The example of a spherically symmetrical particle in a spherical enclosure shows importance of the non-linear wave equation in the author's double solution theory [Abstr. 6483 (1953)]. Points arising from this are briefly elaborated. The possibility of non-linear terms becoming important for the fronts of wave packets is discussed in connection with a causal interpretation. F. ANSBACHER

530.145

97. The wave function of a relativistic system. F. J. DYSON. *Phys. Rev.*, **91,** 1543–50 (*Sept.* 15, 1953).

Three methods of handling problems in relativistic quantum mechanics are discussed. One is the Tamm–Dancoff method, one is the Bethe–Salpeter method, and the third is a new method intermediate between the other two. The connections between the three methods are investigated. It is shown that the new method provides a kind of bridge between the 3- and 4-dimensional points of view. The new method is illustrated with applications to simple examples. A.

530.145

98. A new form for the statistical postulate of quantum mechanics. N. WIENER AND A. SIEGEL. *Phys. Rev.*, **91,** 1551–60 (*Sept.* 15, 1953).

A new type of representation of the wave function of quantum mechanics, and a new form of the statistical interpretation of the wave function, are presented. The variable in the new representation is a mapping of points of differential space, closely related to Hilbert space, but having an associated measure for suitably defined sets of points in it. In the new statistical interpretation, an eigenvalue of every observable defined in the system is associated with each point in differential space. This can be done in such a way that, for each observable, the measure (= probability) of the set of all differential-space points belonging to a given set of eigenvalues is equal to the quantum-mechanical probability, calculated in the usual way (Born statistical postulate), that an experiment will yield an eigenvalue in this set. Thus we obtain an interpretation of quantum mechanics in terms of probability densities or probabilities instead of probability amplitudes. A.

530.145

99. On perturbation and variation methods. R. E. B. MAKINSON AND J. S. TURNER. *Proc. Phys. Soc.* [*London*] *A*, **66,** 857–65 (*Oct.*, 1953).

It is pointed out that the notation of the theory of functionals and the theorem in it analogous to Taylor's theorem facilitates a compact discussion of perturbation and variation methods in quantum mechanics, both for bound state and scattering problems. With this aid it is shown (i) how stationary expressions required for variation methods may be sought and found, (ii) that the perturbation and variation methods are virtually identical, (iii) that second order perturbations and expressions stationary to the second order may be found similarly, though these are complicated. The form found for the second order perturbation of bound states differs from that commonly used in that it does not explicitly involve the eigenfunctions of states other than that perturbed. A.

530.162

100. The negentropy principle of information. L. BRILLOUIN. *J. appl. Phys.*, **24,** 1152–63 (*Sept.*, 1953).

The statistical definition of information is compared with Boltzmann's formula for entropy. The immediate result is that information I corresponds to a negative term in the total entropy S of a system. $S = S_0 - I$. A generalized second principle states that S must always increase. If an experiment yields an increase ΔI of the information concerning a physical system, it must be paid for by a larger increase ΔS_0 in the entropy of the system and its surrounding laboratory. The efficiency $\mathscr{E}$ of the experiment is defined as $\mathscr{E} = \Delta I/\Delta S_0 \leqslant 1$. Moreover, there is a lower limit $k \ln 2$ (k, Boltzmann's constant) for the ΔS_0 required in an observation. Some specific examples are discussed: length or distance measurements, time measurements, observations under a microscope. In all cases it is found that higher accuracy always means lower efficiency. The information ΔI increases as the logarithm of the accuracy, while ΔS_0 goes up faster than the accuracy itself. Exceptional circumstances arise when extremely small distances (of the order of nuclear dimensions) have to be measured, in which case the efficiency drops to exceedingly low values. This stupendous increase in the cost of observation is a new factor that should probably be included in the quantum theory. A.

530.162

101. Energy exchange in molecular collisions. B. WIDOM AND S. H. BAUER. *J. chem. Phys.*, **21,** 1670–85 (*Oct.*, 1953).

A theory was developed for computing the probability of transition, upon molecular collision, between vibrational states, involving corresponding conversion of translational energy. A spherically symmetric Lennard–Jones 6–12 potential for interaction between the colliding molecules was introduced; their relative translational motion was described classically. Further, the theory was symmetrized to permit inclusion of collisions with non-zero impact parameters. As an example, the theory was applied to the CO_2–H_2O system. The effective collision diameter

for an inelastic event was found to be of the observed order of magnitude, demonstrating not only the selective relaxation effect of water, but also its somewhat unusual temperature dependence. Zener's solution of the problem for a head-on collision was generalized to three-dimensional collisions, assuming a spherically symmetric interaction potential; but the complete solution of this model, including a quantum-mechanical description of the relative translational motion, was not obtained. However, for such a potential it was possible to demonstrate that the semi-classical theory is an adequate approximation to the quantum theory result, whenever the relative translational energies are much greater than the energy of exchange. A.

530.162 : 536.7

Fluctuations and irreversible processes. *See Abstr.* 420–1

530.162 : 536.7

102. Logical relations among the principles of statistical mechanics and thermodynamics. J. S. THOMSEN. *Phys. Rev.*, **91**, 1263–6 (*Sept.* 1, 1953).

Five propositions used in thermodynamics and statistical mechanics are formulated: detailed balance, microscopic reversibility, the ergodic hypothesis, the Second Law, and a restriction on the transition probabilities which will be termed the "λ hypothesis." It is shown that the last three propositions are equivalent. The ergodic hypothesis and detailed balance together are proved to be equivalent to microscopic reversibility. This shows that microscopic reversibility is a stronger condition than the Second Law. The results are discussed in connection with Onsager's Principle. A.

530.162 : 539.11

103. A new approximation method for order-disorder problems. L. D. FOSDICK AND H. M. JAMES. *Phys. Rev.*, **91**, 1131–41 (*Sept.* 1, 1953).

The method presented for the treatment of Ising lattices is essentially an extension of Bethe's method, designed to take more direct account of the short-range order in the lattice and to give a better description of this order near the Curie point. Attention is fixed on spin configurations on a small group of sites. Full account is taken of the coupling between these spins, and the effect of coupling to the rest of the lattice is described by means of one or more long-range order parameters, and a correlation parameter characteristic of the method. These parameters are determined as functions of temperature by means of a corresponding number of consistency relations. The method is among the most accurate of the approximation methods in this field, giving about the same accuracy as Kikuchi's method, for a comparable amount of labour; its main advantage over Kikuchi's method lies in the treatment of orientational correlations between relatively remote neighbours in the lattice. The method is here applied to the plane triangular, square and hexagonal Ising lattices, and to the simple cubic lattice. Curie points are determined, and plots of long- and short-range order and the specific heat are given for all but the hexagonal lattice. Like all other approximation methods, this one indicates only a finite discontinuity in the specific heat of the plane lattices at the Curie point, instead of the logarithmic singularity given by exact solutions. Correlation functions for the orientations of up to fifth neighbours are also given for the simple cubic lattice. A.

530.17 : 535.82

Microscope imagery as carrier communication. *See Abstr.* 388

GENERAL MECHANICS . MECHANICS OF SOLIDS 531

531.258 : 518.5 : 621.3.012.8 : 621.317.79

104. A resistance-network analogue method for solving plane stress problems. G. LIEBMANN. Letter in *Nature* [*London*] **172,** 78 (*July* 11, 1953).

An electrical analogue method is described for solving the biharmonic equation, involving the use of two identical resistance networks connected by joining the corresponding nodes through relatively high resistances. An accuracy of a few parts in 10 000 has been achieved experimentally.

J. G. OLDROYD

531.259.2 : 535.55

105. Photoelastic determination of stresses in a cylindrical shell. H. FESSLER AND R. T. ROSE. *Brit. J. appl. Phys.*, **4,** 284 (*Sept.*, 1953).

The correct curves showing tensile circumferential stress plotted against axial distance from juncture are given. Those previously published [Abstr. 4625 (1953)] are incorrect. H. G. JERRARD

531.314.3

106. Small oscillations of a dynamical system. P. ERDÖS. Note in *Z. angew. Math. Phys.*, **4,** *No.* 3, 215–19 (1953) *In German.*

The Hamiltonian differential equations for small displacements of a dynamical system with a finite number of degrees of freedom are solved by use of the methods of linear algebra. In this way the stability of the equilibrium configuration or uniform motion in the case of positive definite total energy is demonstrated. Especially gyroscopic terms may appear in the Hamiltonian, making impossible the usual proof of stability by means of transformation to normal co-ordinates. This method is then applied to the Weierstrass procedure of solution. For use in the above integration, the spectral representation of a matrix with linear elementary divisors is given through the adjoint of its characteristic matrix. A.

MECHANICAL MEASUREMENTS 531.7

531.717.7 : 535.415

On a method of measuring the radii of curvature of spherical surfaces by comparison. *See Abstr.* 357

531.719.1

107. The effective radius of curvature of knife edges. A. L. RAWLINGS; G. F. HODSMAN AND F. A. CHAPPELL. Letters in *J. sci. Instrum.*, **30,** 212 (*June*, 1953).

Rawlings suggests that, following Laplace, the effective axis of suspension of a knife edge lies along

the cylindrical face where it touches the supporting plate. The authors show that the formulae used in their work [Abstr. 8699 (1952)] are justified in view of the magnitudes involved in the design of their apparatus. G. F. HODSMAN

531.743

108. Measurement of the angle between two curves. J. TADAYON. Note in *Rev. sci. Instrum.*, **24**, 871–2 (*Sept.*, 1953).

An instrument is described which allows the accurate measurement of the angle between two curves. A mirror and Dove prism system yield two images of each curve, which can be brought to coincidence by rotation of the Dove prism. A measuring accuracy better than $\pm 0{\cdot}25°$ is claimed. R. W. FISH

531.76

109. Measurements of the speed of little particles in air current. E. LUSCHER. Letter in *Brit. J. appl. Phys.*, **4**, 284–5 (*Sept.*, 1953).

Describes a device for charging a particle as it passes a known point and detecting the charge at a later point. The use of an oscilloscope enables the time interval to be measured. J. M. HOUGH

531.761

110. Phase instrument for measuring time intervals of short duration. F. S. ZAVEL'SKII. *Zh. eksper. teor. Fiz.*, **23**, *No.* 6 (12) 709–11 (1952) *In Russian.*

A description is given of an instrument for measuring short, irregularly varying, time intervals of the order of 10^{-6} to 10^{-8} sec between two subsequent occurrences. The principle of operation is based on the fact that by means of controlled signals two high-frequency generators, tuned to the same frequency, are switched in, one after the other. The lag in the time of connecting the second generator produces a phase shift between the oscillations of the generators. The time interval is determined from this phase difference. E. RABKIN

531.787

111. A differential capacitance manometer. I. G. BAXTER. *J. sci. Instrum.*, **30**, 358–60 (*Oct.*, 1953).

The manometer has been developed for use in a blood flowmeter, to record pressures within the range 0·03–15 mm of mercury developed by a miniature Pitot head; it has a high modulus of volume elasticity to ensure an adequate frequency response. The pressure difference to be measured is applied across a metal diaphragm, the centre of which is linked to a lever that passes through a flexible metal membrane. A capacitance pick-up at the other end of the lever detects movement of the diaphragm. A.

MECHANICS OF FLUIDS 532

532.13

112. The variation of transverse viscosity with shear rate. J. W. BREMNER. Letter in *Proc. Phys. Soc.* [*London*] *B*, **66**, 614 (*July*, 1953).

For a light machine oil it is found that the viscosity associated with relatively small vertical motion of a rotating cylinder viscosimeter is greater than the simultaneously measured horizontal viscosity by 50%. Allowing for a non-Newtonian decrease in the horizontal viscosity, the vertical viscosity appears to have been increased 25% by the rotational motion. R. O. DAVIES

532.13 : 534.23

Second viscosity co-efficient of liquids. *See Abstr.* 171

532.137

113. On the oscillating cylinder viscosimeter. A. A. K. IBRAHIM AND A. M. KABIEL. Letter in *Nuovo Cimento*, **9**, 864–5 (*Sept.*, 1952).

The experimental and theoretical work of Oldroyd, Strawbridge and Toms [Abstr. 3359 (1951)] is quoted, and it is stated that the result of an unpublished calculation is in exact agreement with it. J. G. OLDROYD

532.137 : 621.317.49

114. An electromagnetic viscometer for molten silicates at temperatures up to 1800° C. J. O'M. BOCKRIS AND D. C. LOWE. *J. sci. Instrum.*, **30**, 403–5 (*Nov.* 1953).

Previously reported measurements have been marked by an upper temperature limit of 1650°C and by the poor agreement obtained between different authors working on the same system. The present paper shows how, by the use of molybdenum apparatus, the temperature range may be increased to an upper limit of 1820°C and a method for the measurement of torque, not previously used in this field, permits a higher degree of accuracy than previously attained. It is shown that, of the methods available for room temperature viscosity measurements, a modification of the concentric cylinders method is most suited to adaptation for high temperature measurements on molten silicates, for which the range 0·1–10 000 P is the most important. By the use of an electromagnetic method of torque measurement, it has been found possible to cover the range 0·05–14 000 P without modification of the apparatus and an accuracy of $\pm 0{\cdot}5\%$ has been obtained with the apparatus at room temperature. A method of calibration is demonstrated whereby the apparatus constant is obtained for any depth of liquid and an accuracy of $\pm 6{\cdot}9\%$ with a reproducibility of $\pm 3{\cdot}0\%$ has been obtained at 1800°C. The construction of the apparatus is briefly described and details are given of the operation and method of calibration. A.

532.517 : 534.21

115. Hydrodynamic flow and Oseen's approximation. P. J. WESTERVELT. *J. Acoust. Soc. Amer.*, **25**, 951–3 (*Sept.*, 1953).

It is proved that a linearization of the hydrodynamic equations in the manner of Oseen does not lead to a description of the steady flow phenomena which occur in connection with oscillatory flow past solid obstacles. A.

532.517.4

116. Eddy turbulence and random sound in a compressible fluid. M. S. UBEROI. Note in *Proc. Cambridge Phil. Soc.*, **49**, *Pt* 4, 731–4 (1953).

Moyal [Abstr. 3338 (1952)] has shown that the field variables characterizing homogeneous and isotropic turbulence in a compressible fluid can be

decomposed into two groups, one corresponding to fluctuating acoustical waves, or random sound, and the other to rotational fluctuation velocity or eddy turbulence. The proof is based on special representation of a random field in which random field variables (e.g. velocity) are represented by the expression $u_i(x) = \int \exp(i\kappa \cdot x) dZ_i(\kappa)$. It is now shown that it is not necessary to use this expression to get Moyal's result, and that any turbulence field can be decomposed into two uncorrelated parts, one corresponding to eddy turbulence, the other to random sound. The analysis is based upon the decomposition of any second order tensor into divergence-free and vorticity-free components. J. S. G. THOMAS

532.527

117. Aspects of the turbulence problem. II. H. W. LIEPMANN. *Z. angew. Math. Phys.*, **3**, *No.* 6, 407–26 (1952).

In continuation of previous work [Abstr. 646 (1953)] recent developments in the theory of turbulence relating to transport phenomena and isotropic turbulence are comprehensively reviewed. 107 references. J. S. G. THOMAS

532.527

118. Axial flow in a vortex. J. B. NUTTALL. Letter in *Nature* [*London*] **172,** 582 (*Sept.* 26, 1953).

Swirling fluid flow produced in a vertical Perspex pipe of diameter $2\frac{7}{8}$ in. is shown to be characterized by the occurrence of reverse flow at the axis of the pipe for some rates of swirl and discharge. The phenomenon appears to be related to the reverse flow at the centre of a Ranque–Hilsch vortex tube, although no thermal effects are present. J. S. G. THOMAS

532.543

119. Laminar flow in channels with porous walls. A. S. BERMAN. *J. appl. Phys.*, **24,** 1232–5 (*Sept.*, 1953).

The Navier–Stokes equations have been solved to obtain a complete description of the fluid flow in a channel having a rectangular cross-section and two equally porous walls. The scope has been limited to two-dimensional incompressible steady-state laminar flow. The solution of the flow equations leads to detailed expressions for the dependence of the velocity components and the pressure on position co-ordinates, channel dimensions and fluid properties. A.

532.59

120. Long waves in running water. J. C. BURNS. Appendix by M. J. LIGHTHILL. *Proc. Cambridge Phil. Soc.*, **49,** *Pt* 4, 695–706 (1953).

Classical shallow-water theory for the propagation of long waves in running water is modified by the inclusion of the effects of the vorticity present in the main stream as the result of the action of viscosity. When this vorticity is assumed constant, a non-linear theory can be used, but for more general velocity distributions in the main stream it is necessary to linearize the problem. In the linearized theory, a general equation is obtained connecting the wave velocity with the velocity in the undisturbed stream and this is solved in several special cases. It is shown generally that the wave velocity relative to the mean flow is always greater than the value given by the classical theory. The wave velocity relative to the bottom of the stream has two values, one less than the minimum stream velocity and the other greater than the maximum stream velocity. A.

532.59

121. Multipole expansions in the theory of surface waves. R. C. THORNE. *Proc. Cambridge Phil. Soc.*, **49,** *Pt* 4, 707–16 (1953).

Problems dealing with the generation of surface waves in water involve the consideration of singularities of different types in the liquid; when bodies are present in the liquid, waves may be generated by movement of the body or by reflection therefrom; the resulting motion can be described by singularities placed within the body. The motion arising from line and point singularities in deep and shallow water is discussed, and to ensure uniqueness of the solution the condition is imposed that the motion at infinity is that of a diverging wave. The present paper is concerned with the irrotational motion of a non-viscous incompressible fluid, moving under gravity, with a free upper surface, and the motion is taken to be simple harmonic in time, of small amplitude. The two-dimensional problem is discussed for both symmetrical and antisymmetrical oscillations. The three-dimensional problem is also discussed. Expressions for the potentials are derived in the forms most generally required, and can be expressed in terms of the original singularity, the image singularity in the free surface, and an additional term. A brief bibliography of previous work is given. J. S. G. THOMAS

532.593

122. Application of the notion of group velocity to the propagation of billows on deep water. P. POINCELOT. *Ann. Geophys.*, **9,** 158–60 (*April–June*, 1953) *In French.*

A mathematical justification of the application of the notion of group velocity to the propagation of waves in deep water with a phase velocity $u = (g\lambda/2\pi)^{\frac{1}{2}}$ is developed; the group velocity is $u/2$. The analysis is extended to the discussion of the propagation of a train of sinusoidal waves of pulsation Ω given by $E(t) = (1/2\pi i)\int \exp(i\omega t) d\omega/\omega - \Omega$. The permanent régime is shown to appear suddenly and to be propagated with the group velocity, thus affording a reasonable picture of the course of events in the phenomenon of billowing. At infinity the application of the billowing is rigorously correct; in any actual case it affords a very fair approximation.

J. S. G. THOMAS

532.595

123. Contribution to the study of the oscillation of an ideal liquid in communicating tubes. H.-C. LIU. *Z. angew. Math. Phys.*, **4,** *No.* 3, 185–96 (1953) *In German.*

The oscillation of an ideal liquid in communication tubes of arbitrary shape leads to a non-linear differential equation of second order. The coefficient of the second derivative is a linear function of the displacement, and furthermore the differential equation is not linear, because a quadratic term in the first derivative appears. The equation becomes linear if and only if the cross-sections at the ends of the liquid column are constant but not equal, the periods of oscillation in the two directions are different and the difference increases steadily with increasing amplitude of the displacement. A.

CAPILLARITY 532.6

532.61.08

124. A simple method for the study of variation of boundary tension with time. R. S. Subrahmanya, M. R. A. Rao and B. Sanjiva Rao. *Proc. Indian Acad. Sci. A*, **35**, 136–44 (*March*, 1952).

A new method for the determination of variation of interfacial and surface tensions with time is described. The advantages of the pendant drop method are combined with those of the drop weight method, thus simplifying the experimental technique. Measurements were made with benzene, water and congorubin solutions. The rubin solution yields at the air-liquid interface a solid film and at the solution-benzene interface a gaseous type of film. The effect of concentration of rubin on the variation of interfacial tension with time was studied. At concentrations of rubin higher than 0·0005% the fall in the interfacial tension is large. Salts like sodium chloride and potassium iodide lower considerably the interfacial tension between rubin solution and benzene. Lowering of pH also brings about a fall in interfacial tension. The slow variation of interfacial tension has been accounted for, on the basis of changes in zeta-potential. A.

532.61.08

125. A contribution to the theory of the Langmuir film balance. H. Zierfuss, E. Eisma and P. C. Blokker. Letter in *J. sci. Instrum.*, **30**, 342 (*Sept.*, 1953).

Measurements have not revealed the relatively large errors due to uncertainty in the length of the torsion arm expected by Harkins and Anderson [*J. Amer. Chem. Soc.*, **59**, 2189–97 (*Nov.*, 1937)]. The equations derived enable numerical calculation of the tilt and the immersion of the float due to a decrease in the surface tension on one side to be made, and data given show that for a float of apparent weight 50 mg/cm the length of the arm increases by about 0·004 cm. This can usually be neglected.

G. HOWELLS

532.61.08

126. The reflection method of surface tension measurement. B. G. Kolossvary. *Amer. J. Phys.*, **21**, 510–12 (*Oct.*, 1953).

Attention is called to a method of measuring surface tension of liquids, originally due to Eötvös, and suitable for advanced laboratory practice. The method is recommended when freedom from contamination is otherwise difficult to achieve, and when measurements are desired over a considerable range of temperature. A.

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

127. Atomic distribution functions of liquids. A. Harasima. *J. Phys. Soc. Japan*, **8**, 590–4 (*Sept.–Oct.*, 1953).

These are treated by the cell method. A correlation between the positions of two atoms in neighbouring cells is introduced. By supposing that two atoms, interacting with each other, are in an average field due to other atoms, the authors have derived the form of the first peak of the distribution function. It is shown that a general law can be derived for the temperature dependence of the form of the first peak of the atomic distribution function. A.

532.7 : 530.162

128. The quantum-statistical theory of transport phenomena. I. On the Boltzmann–Uehling–Uhlenbeck equation. H. Mori and S. Ono. *Progr. theor. Phys.*, **8**, 327 (*Sept.* 1, 1952).

By means of the *N*-representation of the density operator, Irving and Zwanzig's equation of motion for the phase-space distribution function is rewritten in such a form that the influence of the symmetry effect appears more explicitly in the collision term of the equation for the singlet distribution function. By means of the customary theory of time-dependent perturbation, the equation of motion for the time-averaged distribution function over an interval as long as the mean life of the unperturbed quantum states, is derived from the Irving–Zwanzig equation. This equation is compared with the Uehling–Uhlenbeck equation, which is obtained as the quantum mechanical modification of the Boltzmann integro-differential equation by means of a physical argument. (It is concluded that the deviation from the Uehling–Uhlenbeck equation becomes important if the local variation of the external field or of the distribution function in the range of the order of magnitude of the de Broglie wavelength is appreciable.) It seems probable that the Uehling–Uhlenbeck equation becomes invalid at extremely low temperatures, such as the λ-point of liquid helium. The authors have, however, not succeeded in the derivation of an equation for the general case, because the postulate of random *a priori* phases destroys the dependence of the initial distribution on co-ordinates. A.

532.72

129. The diffusion of iodine in carbon tetrachloride under pressure. E. W. Haycock, B. J. Alder and J. H. Hildebrand. *J. chem. Phys.*, **21**, 1601–7 (*Sept.*, 1953).

The diffusion of iodine in carbon tetrachloride was studied over a temperature range from 10 to 55°C and a pressure range from 1 to 200 atmospheres by the capillary cell technique and by an optical comparison method. The results of the two methods agree well, and the data can be represented by an activation energy at constant pressure of 3300 cal/mole compared to an activation energy at constant volume of 1070 cal/mole. A.

MECHANICS OF GASES 533

533.1

130. A robust air-flow meter for field use. D. S. M. Phillips. *J. sci. Instrum.*, **30**, 382–3 (*Oct.*, 1953).

An unusual type of air-flow meter is described which employs a series of small metering orifices as flow controls at a fixed pressure. The meter was designed for use in milking machine tests where air-flow levels in the range of 0–50 ft^3/min are encountered

at a negative pressure of 15 in. of mercury. Apart from its use in this field, the instrument could have many applications in industry where a robust portable instrument is required. A.

533.275

131. The performance of thermistor hygrometers under tropical conditions. G. W. SMITH. *J. sci. Instrum.*, **30**, 414–18 (*Nov.*, 1953).

The thermistor hygrometer described by Penman and Long [Abstr. 2229 (1949)] has been tested against a standard Assman psychrometer, under tropical conditions. It is shown that the instrument is not reliable unless used in the shade. Several modifications are described, and proposals are put forward for improving the performance in high light intensities. Penman and Long's correction was found to be invalid in the range of temperatures studied. The hygrometer is very convenient for use in humidity investigations, particularly where a small instrument is required. A.

533.5

132. An electrical analogue to a high vacuum system. M. J. AITKEN. Letter in *Brit. J. appl. Phys.*, **4**, 188 (*June*, 1953).

Can be used in a complex vacuum system to calculate the effect on the pressure of altering various parts of the pumping system and to localize a leak, provided the pressure is low enough for the mean free path to be larger than the dimensions of the system. G. WITTENBERG

533.5

133. A combination high-vacuum and pressure valve. E. G. REILLY. Note in *Rev. sci. Instrum.*, **24**, 875–6 (*Sept.*, 1953).

Diagram and detailed description of gas filling and shutoff valve, designed for counters, which seals a gas pressure of 400 lb/in.^{2} against a vacuum of 6×10^{-6} mm Hg applied in either direction. G. WITTENBERG

533.5

134. A vibrating needle variable gas leak. A. J. STINNETT. Note in *Rev. sci. Instrum.*, **24**, 883–4 (*Sept.*, 1953).

A hardened steel needle, vibrated axially by means of a solenoid supplied with a.c., opens and closes, at double the frequency of the current supply, an orifice in the needle seating. The device was designed to introduce bursts of gas into the vacuum chamber of an electron diffraction camera, but is considered to have wide usefulness. J. S. G. THOMAS

533.6.01

135. Mach reflexion of shocks at arbitrary incidence. H. F. LUDLOFF AND M. B. FRIEDMAN. Letter in *J. appl. Phys.*, **24**, 1247–8 (*Sept.*, 1953).

The Mach reflexion of shocks from finite corners leads to a difficult non-linear boundary value problem, the four differential equations of which are stated in terms of the conservation of (1) mass, (2) momentum and (3) energy. From the last of these it is deduced that the "streamlines" are isentrops. The location of the reflected and Mach shocks and of the slipstream are not known *a priori*, but at the boundaries the four conservation equations must be fulfilled. This yields four conditions on the shocks and two on the slipstream. On the symmetry line and on the wa one condition only is imposed, viz. the usual require ment of tangential flow velocity. Dropping on boundary condition temporarily, three conditions ar imposed on the shocks, one on the wall and one on th slipstream. A numerical solution of the resulting non linear system of equations is derived by supplementin the equations by so-called dependent condition which are an expression of the validity of the differentia equations at the boundary. General properties of th solution are briefly discussed. J. S. G. THOMA

533.6.01

136. On the flow of a viscous fluid past an incline elliptic cylinder at small Reynolds numbers. H HASIMOTO. *J. Phys. Soc. Japan*, **8**, 653–61 (*Sept.–Oct* 1953).

The steady flow of a viscous fluid past an ellipti cylinder set at an arbitrarily given angle to the uniform flow, is discussed on the basis of Oseen's linearize equation of motion, using elliptic co-ordinates. Ne fundamental solutions for the stream function a obtained. The expansion formulae for the lift an drag in powers of Reynolds numbers are obtained, an coincide perfectly with Imai's formulae obtained by new expansion method using complex variables.

533.6.011.3 : 534.

Acoustic streaming at high and low Reynol numbers. *See Abstr.* 158–9

533.6.011.3 : 534.

Acoustic streaming equations: Laws of rotatio motion for fluid elements. *See Abstr.* 160

533.6.011.3

137. Improvement of the differences method H. Görtler for the calculation of laminar bound layers. H. WITTING. *Z. angew Math. Phys.*, **4**, *No* 376–97 (1953) *In German.*

This method (1948), for the calculation of lami boundary layers of plane, steady and incompress flow functions in the neighbourhood of the poin separation holds only with a reduced degree exactness. The same holds for the method K. Schröder (1951). This is due to the displacen of a line of indetermination of the expression fo continuation as a result of the finite approximat used. This defect is overcome by means of a p nomial approximation of the velocity distributio the neighbourhood of the wall, and in addition sensitivity of the method with respect to propaga of errors is generally reduced. The relatively s increase in labour is more than offset by the incre degree of exactness. The splitting phenomena inh in the above-mentioned methods may be avoide means of a suitable smoothing process. The me has been tried with success on several examples.

MOLECULAR THEORY OF GASES 53

138. Random walk theory of one-dimensional C. W. HARRIS, R. L. SELLS AND E. GUTH. Le *J. chem. Phys.*, **21**, 1617–18 (*Sept.*, 1953).

It is pointed out that the problems consider

he authors [Abstr. 8244 (1953)] and by Salsburg, Zwanzig and Kirkwood [Abstr. 5904 (1953)], relating o the partition function of a one-dimensional gas vith nearest neighbour interaction, can be regarded is special cases of the general one-dimensional random valk problem. E. H. SONDHEIMER

533.7

139. The second virial coefficient near absolute zero. D. TER HAAR. Letter in *Proc. Phys. Soc.* [*London*] *A*, 66, 847–8 (*Sept.*, 1953).

Criticism of a statement by H. S. Green [Abstr. 2258 (1953)] concerning the status of earlier calculations of *B*. E. H. SONDHEIMER

533.7 : 530.162

140. On the radial distribution function of a compressed gas of rigid spheres. B. R. A. NIJBOER AND R. FIESCHI. Letter in *Physica*, **19**, 545–7 (*June*, 1953).

The accuracy of the superposition assumption of Born and Green [Abstr. 771 (1947)] and of the netted-chain approximation of Rushbrooke and Scoins [Abstr. 3004 (1953)] is tested by comparing the values of the virial coefficients obtained by use of the virial theorem with the values obtained from the compressibility integral. It appears that neither approximation is satisfactory when higher powers of the density are considered. E. H. SONDHEIMER

VIBRATIONS . ACOUSTICS 534

534.014.2

141. An experiment in mechanical resonance vibrations. B. D. MCDANIEL. *Amer. J. Phys.*, **21**, 551–5 (*Oct.*, 1953).

An apparatus suitable for an elementary laboratory experiment on mechanical, forced, damped oscillations is described. Sample results with this apparatus show four ways of measuring Q and three ways of measuring the resonance frequency of the system with good agreement among the results. A.

534.015

142. Anharmonic resonance. H. JEHLE AND J. H. CAHN. *Amer. J. Phys.*, **21**, 526–31 (*Oct.*, 1953).

The oscillations of a pair of classical oscillators which are synchronized because of anharmonic resonance can be calculated by the method of variation of constants. Two types of motion are studied: librational and non-librational—referring to oscillatory and progressive behaviour, respectively, of the phase difference of the two oscillators. These motions are exemplified by the corresponding motion of a rod pendulum. Conditions for prolonged persistence of librational motion are discussed. This paper is essentially a review of some of E. W. Brown's papers on non-linear resonance (1932). A.

534.1

143. Some solutions of the wave equation. B. R. SETH. *Proc. Indian Acad. Sci. A*, **32**, 421–3 (*Dec.*, 1950).

534.112

144. On the non-linear theory of the vibrating cord. H. MÜLLER. *Ann. Phys.* [*Leipzig*] **12**, *No.* 7–8, 398–400 (1953) *In German.*

A brief discussion of the differential equations of a vibrating cord, interpreted mainly in terms of a physical model. H. J. H. STARKS

534.112

145. Effect of stiffness and nonuniformity on vibroscopic determination of filament cross-sectional area. D. J. MONTGOMERY. *J. appl. Phys.*, **24**, 1092–9 (*Sept.*, 1953).

The presence of stiffness in a stretched string vibrating between fixed supports raises all the natural frequencies over those for a perfectly flexible string. The presence of non-uniformity in cross-sectional area along the string changes some or all of the frequencies from those for a perfectly uniform string, the amount and direction of change depending on the form of the non-uniformity. These changes in frequency may introduce error into the calculation of the average cross-sectional area of a fibre, by means of the vibroscopic technique, wherein the mechanical resonance of a stretched fibre is observed under oscillating mechanical or electrostatic forces. In this paper the natural frequencies are calculated with both the stiffness and the non-uniformity taken into account to first-order terms. The relation between the average cross-sectional area and the natural frequencies is analysed. Consideration is given to the manner in which the changes in frequency and shifts of the nodes, due to non-uniformity, determine the detailed form of the area variation. The characterization of non-uniformities in terms of certain arbitrary parameters is shown to lead to the possibility of calculating the average area by measuring the natural frequencies in only the first and second modes and of calculating the maximum or minimum area by measuring also the nodal shift in the second mode. A.

534.121.1

146. Epicentral displacement caused by elastic waves in an infinite slab. A. G. MENCHER. *J. appl. Phys.*, **24**, 1240–6 (*Sept.*, 1953).

The displacement is determined at the epicentre of a homogeneous isotropic infinitely long elastic slab containing a point source of pressure waves. The source is centrally located between the slab surfaces and is taken to have a step function time dependence. The formal solution for the Laplace transform of the displacement is obtained as an infinite integral. The integration and the inversion are simultaneously accomplished by an infinite series expansion of the integrand and transformation of variables for each term of the expansion. The resultant integrated series consists of terms having the mathematical form of reflected waves which diverge individually but combine to give a finite resultant. In view of the fact that the expansion of the integrand is not valid at the upper limit of integration, a justification of the method and of the results is given. A.

534.121.2

147. On the vibration of mass-loaded membranes. E. T. KORNHAUSER AND D. MINTZER. *J. Acoust. Soc. Amer.*, **25**, 903–6 (*Sept.*, 1953).

The conventional treatment of a vibrating membrane with a small mass load, originated by Rayleigh, leads to perturbed eigenfrequencies slightly lower than the unperturbed values and independent of the

area of the load so long as it is small compared to the area of the membrane. It is shown that this result is incorrect because of an invalid initial assumption about the amplitude of vibration of the load. Actually the perturbed frequencies are slightly higher than the unperturbed values, depend upon the area of the load, and approach the unperturbed values as the load approaches a point mass. In addition a very low frequency mode exists whose frequency approaches zero as the load becomes smaller in area; this mode represents a perturbation of the trivial zero-frequency solution in the unperturbed case. The special case of a circular membrane loaded at the centre is discussed in some detail. A.

534.13

148. Signals in a borehole due to plane waves in the solid. J. E. WHITE. *J. Acoust. Soc. Amer.*, **25**, 906–15 (*Sept.*, 1953).

Presents a theory describing the acoustic waves set up in a fluid-filled borehole by the passage of plane elastic waves in the surrounding solid. It consists of a mathematical development of the following process. A stress in the solid around the borehole will in general cause the hole to contract or expand. A contraction compresses the fluid and causes pulses to radiate in both directions as tube waves. At some observation point, one of these pulses is observed after a delay due to the propagation as a tube wave. A complex wave in the solid is expressed as a combination of stresses distributed along elementary lengths of the borehole, and the total acoustic wave received at a point is expressed as the summation of elementary pulses arriving after suitable delays. The expressions derived give pressure or fluid particle velocity in terms of motion or stresses in the solid for plane compressional waves and plane shear waves arriving at any angle. The method can be extended to the case of a spherical wave cutting the borehole. A.

534.13

149. Principal frequencies of a double spring-mass system. W. PONG. *Amer. J. Phys.*, **21**, 546–8 (*Oct.*, 1953).

The object is to show how the masses of the springs will affect the principal frequencies of a double spring-mass system. The frequency equation for the system is first derived from a set of assigned boundary conditions. Then with the assumption that the mass of each spring is relatively small, a special case is considered. It is shown by approximation that the mass of the spring has the equivalent effect of changing the main mass by an amount which depends on the modes of oscillations. A.

534.133

150. On the theory of excitation of thickness vibrations of piezoelectric crystal plates. R. MEIER AND K. SCHUSTER. *Ann. Phys.* [*Leipzig*] **12**, *No.* 7–8, 386–92 (1953) *In German.*

The laws governing the thickness vibrations of an infinite crystal plate are derived, special consideration being given to the 3 cases of most practical importance. A study of the relation between the acoustic output and the mechanical and electrical properties of the crystal element indicates the most desirable kind of medium for producing the maximum acoustic output from a given crystal. H. J. H. STARK

534.133

151. On the excitation of thickness vibrations with ammonium phosphate crystal plates. R. MEIER AND H. TROMMLER. *Ann. Phys.* [*Leipzig*] **12**, *No.* 7–8 393–7 (1953) *In German.*

Photographs of the thickness vibrations of *L*-cu ADP crystals indicate that this method of using ADI is not suitable for ultrasonic work. H. J. H. STARK

534.2

152. Transformer couplings for equivalent networ synthesis. B. B. BAUER. *J. Acoust. Soc. Amer.*, 25 837–40 (*Sept.*, 1953).

It may be shown that regardless of the type o analogy chosen ("impedance" *v.* "mobility"), dis conformity will be encountered in synthesizing th equivalent network of a mechano-acoustic array. method is described employing transformer coupling for getting round this difficulty. As a result, becomes possible to construct equivalent circuits mechanical arrays in a simple and straightforwar manner by the method of impedance analogy. Simila benefits are achieved for the method of mobili analogy in the synthesis of equivalent circuits acoustic arrays. Equivalent networks for certa mechano-acoustic arrays which cannot be conve tionally synthesized become feasible through th method.

534.

153. Equivalent network representations for solid a mercury delay lines. S. DAIRIKI, T. E. LAWRENCE A R. A. MAPLETON. *J. Acoust. Soc. Amer.*, **25**, 841 (*Sept.*, 1953).

An equivalent network representation is derived mercury and solid delay lines. A transfer funct that relates output voltage to input voltage is quantity selected to represent the delay line, and transfer function is derivable from a matrix equati Mercury and solid delay lines are compared in te of the gain-bandwidth product of the delay line. comparison is extended to include factors not pre in the circuit representation. Other topics discu are third-time-around signals, acoustic transform glued crystals, input impedance, wave propagation diffraction. The final selection between solid mercury delay lines is determined by the spe application.

53

154. Wave propagation in a randomly inhomogen medium. I. D. MINTZER. *J. Acoust. Soc. Amer* 922–7 (*Sept.*, 1953).

The propagation of sound pulses from a source in a medium where the index of refra varies randomly is studied by means of the approximation to the wave equation. The coeff of variation (standard deviation of the amplitu a series of pulses, expressed as a percentage mean amplitude of the series) is evaluated for lengths short compared with the time in whic refractive index varies significantly, and for large compared with the wavelength of the s The results are in agreement with the experime Sheehy.

534.21

155. Ray theory for moving fluids. E. T. Kornhauser. *J. Acoust. Soc. Amer.*, **25**, 945–9 (*Sept.*, 1953).

The generalized eikonal equation for moving fluids is obtained from a very simple physical argument. Elementary solutions for uniformly moving media are discussed. A generalized form of Snell's law is derived, and it is specialized in three separate ways to yield formulae useful for solution of problems in stratified media. Examples of its application are given in each case. A.

534.21

156. Propagation of acoustic discontinuities in an inhomogeneous moving liquid medium. G. S. Heller. *J. Acoust. Soc. Amer.*, **25**, 950–1 (*Sept.*, 1953).

It is shown that a surface in a moving inhomogeneous liquid on which the time derivatives of pressure and velocity are discontinuous must propagate according to a generalized eikonal equation. The usual assumption of infinitesimal amplitudes is not required in this treatment. A.

534.21

157. Propagation of radiation in an inhomogeneous medium near an irregular surface. W. C. Meecham. Letter in *J. Acoust. Soc. Amer.*, **25**, 1012 (*Sept.*, 1953).

The intensity of a sound wave propagated in a surface channel is derived using the concepts of ray acoustics and taking into account the roughness of the surface. The attenuation due to rough surface scattering is found and calculations are made for several types of surface reflections. A.

534.21 : 532.517

Hydrodynamic flow and Oseen's approximation. *See Abstr.* 115

534.21 : 533.6.011.3

158. Acoustic streaming at high Reynolds numbers. J. M. Andres and U. Ingard. *J. Acoust. Soc. Amer.*, **25**, 928–32 (*Sept.*, 1953).

The apparent discrepancies between the observations of Andrade and Schlichting and those of Carrière with regard to the direction of acoustic streaming near obstacles has been re-examined. It is pointed out that the geometry of the streaming is determined by the two dimensionless parameters $R = U_0^2/\nu$ and s/a, where R is the Reynolds number, U_0 the velocity amplitude of the incident wave, a the characteristic length of the obstacle (radius of cylinder), ν the kinematic viscosity and s the displacement amplitude of the incident sound wave. It is found that the Andrade–Schlichting observations correspond to large values of R ($\sim$1000), whereas the Carrière observations correspond to small values of R ($\sim$10). The present paper deals specifically with the theory for large R and extends the work of Schlichting to discuss the distortion of the flow pattern as a function of the sound intensity. The results obtained are found to be in agreement with experiments. A.

534.21 : 533.6.011.3

159. Acoustic streaming at low Reynolds numbers. J. M. Andres and U. Ingard. *J. Acoust. Soc. Amer.*, **25**, 932–8 (*Sept.*, 1953).

The corresponding problem for low Reynolds numbers (order of ten) is now considered, and it is shown that the flow pattern obtained around a cylinder in a sound field is opposite to the one corresponding to high Reynolds numbers. The Reynolds number is defined as $R = U_0 a/\nu$, where U_0 is the particle velocity in the incident sound wave, a is the radius of the cylinder, and ν is the kinematic viscosity. The two types of flow associated with different values of Reynolds numbers seem to correspond to the two types of circulations that have been experimentally observed and reported in the literature. A.

534.21 : 533.6.011.3

160. Acoustic streaming equations: laws of rotational motion for fluid elements. W. L. Nyborg. *J. Acoust. Soc. Amer.*, **25**, 938–44 (*Sept.*, 1953).

It is shown that the third-order differential equations commonly used in connection with acoustic streaming are special approximations to the law of rotational motion for a fluid element. An expression is derived for the torque exerted by stresses on a spherical element of fluid, about its centre of gravity. The average torque in a steady state sound field consists partly of (1) a sonic torque, exerted by the sound field and partly of (2) a viscous torque due to the induced steady flow. Expressions are also derived for the instantaneous rate of increase of moment of momentum of a spherical fluid element, due to angular acceleration, expansion and shearing. Interpretation is given to individual terms in various streaming equations. In general, any field consisting of superposed elementary waves will give rise to a non-zero distribution of sonic torque. In the special case of a directional source the distribution is similar to that of the gradient of the magnitude of radiation pressure. A.

534.211

161. Wave propagation in finite rods of viscoelastic material. E. H. Lee and I. Kanter. *J. appl. Phys.*, **24**, 1115–22 (*Sept.*, 1953).

The paper is concerned in the main with a Maxwell material, which corresponds to a model having a spring and dashpot in series. The equation for longitudinal wave propagation in rods is shown to be equivalent to the telegraph equation, and solutions of transient wave problems are treated briefly in the Appendix using the Laplace transform technique. Impact on a semi-infinite rod is considered in detail in the report. A method of superposition of images is discussed to use this solution to solve boundary value problems for finite rods. The resulting stress distributions are discussed and contrasted with those for an elastic rod. The natural grouping of problems is discussed according to the relative magnitude of the duration of interest, the relaxation time and the wave traverse time. The influence of the idealization involved in the Maxwell model is briefly touched upon. A.

534.213.4

162. The theory of the propagation of plane sound waves in tubes. D. E. Weston. *Proc. Phys. Soc. [London] B*, **66**, 695–709 (*Aug.*, 1953).

The propagation of plane sound waves in gases in tubes can be divided into three main types, depending on the radius and frequency involved. These types are described as "narrow" tube, "wide" tube and "very wide" tube propagation. The phase velocity, attenuation and cross-section profile of particle

velocity, etc., are investigated theoretically, and their interrelation pointed out. The factors affecting the validity of Kirchhoff's formulae are considered and the theory is applied to some recent work. A.

534.213.4

163. Experiments on the propagation of plane sound waves in tubes. I. The adiabatic region. D. E. WESTON. **II. The transition region.** D. E. WESTON AND I. D. CAMPBELL. *Proc. Phys. Soc.* [*London*] *B*, **66**, 769–74 (*Sept.*, 1953).

I. An experimental investigation using an acoustic interferometer with a magnetostriction source is described. Results on attenuation and velocity in tubes of radius 0·013 cm and upwards, from 10 to 20 kc/s, and for a variety of tube materials and gases are given. These confirm modified Kirchhoff's formulae. II. The velocity and attenuation of plane sound waves in tubes of radius 0·02 cm have been measured in the transition region between adiabatic and isothermal flow. A.

534.22

164. The velocity of sound in air at low pressures. D. E. CARO AND L. H. MARTIN. *Proc. Phys. Soc.* [*London*] *B*, **66**, 760–8 (*Sept.*, 1953).

Measurements of the velocity of sound in tubes have been made in air over a range of pressures extending down to 5 mm Hg at frequencies of 250 c/s and 1000 c/s. The method employed was to measure the time of transit of a sinusoidal pulse between two condenser microphones separated by a distance of approximately 4 metres. After tube and gas corrections were made it was found that the velocity was independent of pressure between 760 mm Hg and 5 mm Hg. The mean velocity at 20°c obtained is $343{\cdot}40 \pm 0{\cdot}02$ m sec^{-1} which is in good agreement with the generally accepted value $343{\cdot}42 \pm 0{\cdot}07$ m sec^{-1} obtained by Hardy *et al.* (1942) for dry air free from carbon dioxide. No evidence was found of the increase in velocity at low pressures observed by Abbey and Barlow (1948) and by Maulard (1949). A.

534.22 : 534.23

165. Temperature variation of velocity and absorption coefficient of ultrasonic waves in heavy water (D_2O). M. PANCHOLY. *J. Acoust. Soc. Amer.*, **25**, 1003–6 (*Sept.*, 1953).

The coefficient of absorption and velocity of propagation were measured in D_2O at 50·22 Mc/s as functions of temperature. Velocity values are lower than those in H_2O at corresponding temperature by about 100 m/sec but measurements extended to 90° show a striking qualitative similarity between velocity *v.* temperature curves for D_2O and H_2O. The value of the frequency-free absorption coefficient $2\alpha/\nu^2$ varies from 124×10^{-17} to 27×10^{-17} cm^{-1}sec^2 over the temperature range of 5° to 50°c. The mean value of the ratio of measured value to classical value is 2·87 against 3·12 for H_2O. A.

534.22 : 537.312.62

166. Velocity of sound in superconducting lead and tin. H. BÖMMEL AND J. L. OLSEN. Letter in *Phys. Rev.*, **91**, 1017 (*Aug.* 15, 1953).

No change in velocity of sound greater than 1 part in 2×10^4 was found in tin or lead at 1 Mc/s when superconductivity was destroyed at various temperatures and magnetic fields. Although a change of only 1 part in 10^5 is to be expected at low frequencies from the expected change in the static elastic constants, a greater change might occur according to Fröhlich's theory at frequencies characteristic of thermal oscillations ($\sim10^4$ Mc/s). D. SHOENBERG

534.222 : 534.152

167. Free surface motion induced by shock waves in steel. W. A. ALLEN. *J. appl. Phys.*, **24**, 1180–5 (*Sept.*, 1953).

An optical technique [Abstr. 3035 (1953)] has been used to measure surface oscillations on a series of thick 5·5 in. diam. steel plates of different thicknesses while they deform under explosive attack. Data obtained from the four 1025 steel specimens illustrated in the previous paper, and data obtained from two additional specimens have been analysed partially. Results are compared with predictions from the theory of elasticity for the case of a diverging pulse. Elementary theory, known to be incorrect in the physical regime studied, is shown to give many satisfactory predictions for large distances from the charge. A.

534.222.2

168. On the attenuation of a repeated sawtooth shock wave. I. RUDNICK. Letter in *J. Acoust. Soc. Amer.*, **25**, 1012–13 (*Sept.*, 1953).

A formula which describes the space rate of change of amplitude of a repeated finite amplitude sawtooth wave is derived by application of the Rankine–Hugoniot shock relations. Experimental evidence is in agreement as to the form of the amplitude change but gives lower rates of change than indicated by the formula. A.

534.222.2

169. Generation of weak shock waves. V. TIMBRELL. Letter in *Nature* [*London*] **172**, 540–1 (*Sept.* 19, 1953).

Because of the non-linearity of the pressure-volume relationship for air, different parts of a sound wave of finite amplitude travel at different velocities. The wave distorts as it advances and shock-fronts may be produced. Sound pulses which distort at a rate convenient for investigation of the phenomenon are generated by discharging a condenser through the moving coil of a loudspeaker. The author shows that a modification of the Stokes theoretical construction for the distortion agrees closely with experimental results. A. B. WOOD

534.222.2

170. On the propagation and structure of the blast wave. I. A. SAKURAI. *J. Phys. Soc. Japan*, **8**, 662–9 (*Sept.–Oct.*, 1953).

Concerning blast waves with front surfaces of plane, cylindrical and spherical shape, the propagation velocity U and the distribution of hydrodynamical quantities are discussed. The solutions are constructed in the form of power series in $(C/U)^2$, where C is the sound velocity of undisturbed fluid. R, the distance of shock front from the charge, is represented as,

$$\left(\frac{C}{U}\right)^2\left(\frac{R_0}{R}\right)^{\alpha+1} = J_0\left[1+\lambda_1\left(\frac{C}{U}\right)^2+\frac{1}{2}\lambda_2\left(\frac{C}{U}\right)^4+\cdots\right],$$

where R_0 is the characteristic length related to the energy of explosion, J_0 and λ_i are constants and

$\alpha = 0, 1, 2$ correspond to plane, cylindrical and spherical case, respectively. The first approximations for $\alpha = 0, 1$ are discussed. The solution is obtained numerically for the case of the adiabatic index $\gamma = 1{\cdot}4$. The approximate solution is also considered. A.

534.23 : 532.13

171. Second viscosity coefficient of liquids. S. M. Karim. *J. Acoust. Soc. Amer.*, **25**, 997–1002 (*Sept.*, 1953).

It is known that the experimental value of the absorption of ultrasonic waves in most liquids is in excess of the theoretically calculated one. While attempts have been made to explain the discrepancy in different ways, a phenomenological approach is through the second viscosity coefficient. Recently Eckart has discussed the streaming set up in a liquid when a beam of ultrasonic waves passes through it, and has shown that it is dependent on both the bulk and shear viscosities. The conclusions arrived at from an experimental investigation carried out on the basis of Eckart's theory are: 1. The value of the ratio of second viscosity to shear viscosity is positive in conformity with the theory. 2. The agreement between experimental and theoretical values is closer in the case of pure liquids than in the case of solutions. For pure liquids the value of μ', the second viscosity, appears generally to be greater than the value of μ, the shear viscosity, at ordinary pressures and temperatures. 3. The values of μ' as obtained by experiment and as calculated from the excess sound absorption data are in fair agreement in the case of the liquids used. 4. In some solutions the two coefficients are either equal or the shear viscosity is the greater. 5. The values of μ'/μ obtained by independent workers with different methods are in fair agreement. Although the anomalous absorption of sound may be accounted for by the second viscosity coefficient, more data are necessary before a final conclusion can be drawn as regards the precise mechanism of the sound absorption. A.

534.231

172. End corrections for a concentric circular orifice in a circular tube. G. B. Thurston and J. K. Wood. *J. Acoust. Soc. Amer.*, **25**, 861–3 (*Sept.*, 1953).

The results of an experimental investigation of the end corrections for acoustic resistance and acoustic inertance for a concentric circular opening in a partition in a circular tube are presented. The end corrections are taken to be that length which must be added to the geometrical length of the orifice when introduced into an expression for the acoustic impedance. This expression can be derived on consideration of a tube of infinite length filled with a viscous, incompressible fluid. Used in this manner, the two end corrections are found to take on the same values, these values agreeing with those derived for inertance on the basis of the mass contribution due to higher order waves in the tube, treating the orifice as a plane piston source. Graphical criteria for the onset of measurable nonlinearity are presented. A.

534.231

173. The sound field of a moving source. H. Zatzkis. *J. Acoust. Soc. Amer.*, **25**, 897–8 (*Sept.*, 1953).

The sound field generated by an ellipsoidal vibrator, moving with constant velocity, is examined. The solution has the form of an infinite series. The first term of the series agrees with the solution for a point source, established by previous investigators. A.

534.231.3

174. The impedance of a resistance-loaded Helmholtz resonator. U. Ingard and R. H. Lyon. *J. Acoust. Soc. Amer.*, **25**, 854–7 (*Sept.*, 1953).

The impedance of a Helmholtz resonator damped by a thin porous layer in the form of a screen or cloth is calculated as a function of the distance between the aperture and the screen. It is shown that the input resistance of the resonator decreases very fast as the distance between the screen and aperture increases, whereas the aperture mass reactance passes through a maximum. The importance of these results with regard to design of resonators and perforated facings is discussed. A.

534.231.3

175. Acoustic impedance of rectangular tubes. J. K. Wood and G. B. Thurston. *J. Acoust. Soc. Amer.*, **25**, 858–60 (*Sept.*, 1953).

An expression for the acoustic impedance of a section of infinite parallel planes is derived. Measured values of the impedance of long narrow rectangular tubes show good agreement with this theory when an appropriate end correction is used. The theory compares favourably with impedance measurements on short rectangular tubes or slits even when the effective length of the slit is $3{\cdot}7$ times the geometric length. A.

534.232

176. Optimum directivity patterns for linear point arrays. R. L. Pritchard. *J. Acoust. Soc. Amer.*, **25**, 879–91 (*Sept.*, 1953).

The sharpest major lobe of a directivity pattern due to a linear array of equally-spaced point elements is achieved when the elements are excited in such a manner that all minor lobes in the pattern have the same relative amplitude. Methods of producing such equal-minor-lobe patterns originally given in the radio literature by Dolph and by Riblet are summarized briefly in this paper. In particular, the synthesis method indicated by Riblet is described in general terms, and the effect of the element spacing is discussed in detail. Included in this discussion is the subject of super-directivity. Results of numerical calculations based on these methods are presented as families of curves showing the relationships existing among angular width of the major lobe, relative amplitude of the equal minor lobes, directivity index, and number and spacing of the elements in the array for 5–13 odd numbers of elements. In addition, the synthesis methods are extended to compensated, or steered, arrays. A.

534.232

177. Approximate calculation of the directivity factor of linear point arrays. R. L. Pritchard. Letter in *J. Acoust. Soc. Amer.*, **25**, 1010–11 (*Sept.*, 1953).

An approximate method of calculation is developed in which the reciprocal of the directivity factor of a linear array of equi-spaced point elements is interpreted as an area beneath the curve of the square of the directional characteristic (relative sound pressure at a large fixed distance) expressed as a function of an

auxiliary variable. Data required for the approximate calculation are the spacing between the elements of the array, their relative excitation, the beam width of the pattern, and the value of the average amplitude of the minor lobes of the pattern. The utility of the method is illustrated by a numerical example: a broadside array of 13 uniformly-excited elements with a relative spacing of $d/\lambda = 7/8$. The directivity index obtained by the approximate method described agrees within 0·3 db of the exact value. A. B. WOOD

534.232

178. On the measurement of power radiated from an acoustic source. W. G. CADY AND C. E. GITTINGS. *J. Acoust. Soc. Amer.*, **25**, 892–6 (*Sept.*, 1953).

Describes an experimental test of the theory that the total force on an absorber receiving a beam of plane waves is a measure of the acoustic power generated at the source, provided that certain conditions are satisfied. The exponential decay in acoustic intensity is accompanied by a corresponding exponential increase in the force due to the hydrodynamic flow, as has been verified experimentally. The sum of these two forces, plus a possible further force that may exist at the emitting surface due to local hydrodynamic conditions or to a "pumping effect," should be independent of the distance from the source to the absorber. The verification of this prediction is the chief result of the investigation. From the results it can also be inferred that the "pumping effect," if it exists at all, is probably very small in liquids. As absorbers, a slab of ρc-rubber, a 90° wedge and a cavity radiometer were used. The reacting force on the transducer was also measured, and found, within the limits of measurement, to be equal to that on the absorber. This result indicates that acoustic power can be measured by observing this reacting force without the need of an absorbing system. A.

534.232

179. Intensities produced by jet-type ultrasonic vibrators. H. O. MONSON AND R. C. BINDER. *J. Acoust. Soc. Amer.*, **25**, 1007–9 (*Sept.*, 1953).

Intensity and frequency measurements were made with different jet-type generators. High values of intensity were reached at certain nozzle inlet pressures, certain cup positions and with certain proportions of the generator. A.

534.232

180. The theoretical sensitivity of three types of rectangular bimorph transducer. E. G. THURSTON. *J. Acoust. Soc. Amer.*, **25**, 870–2 (*Sept.*, 1953).

The theoretical sensitivity for operation below resonance of three types of rectangular, bimorph transducer elements is derived using the results of elasticity theory. The cases treated are first, the widely used corner-loaded square bimorph; second, the rectangular bimorph simply supported along two sides and uniformly, transversely loaded; and third, the latter loaded only over a strip in its centre. A.

534.232

181. Barium titanate admittance-temperature characteristics. A. L. LANE. *J. Acoust. Soc. Amer.*, **25**, 873–8 (*Sept.*, 1953).

Describes the temperature effects on the admittance of barium titanate transducers operating near resonance. Both "pure" and leaded ceramic mixtures are compared over the 0–20°C temperature range. Some results of calcium additives are also given. Despite extreme fluctuations of the dielectric and piezoelectric constants over this temperature range, it is possible at certain frequencies near resonance for the transducer conductance and susceptance to vary very little with temperature. Water admittance circle diagrams and power-frequency curves—all plotted at different temperatures—are presented and analysed from an equivalent circuit point of view. One of the significant conclusions derived from this experiment is that the radiated power of even a pure ceramic transmitting transducer, properly matched to its source at this optimum frequency, will remain maximized regardless of the temperature variation. While the barium titanate temperature effects were studied for given underwater transducers, the information outlined is of value to anyone encountering temperature variations in a resonant barium-titanate ceramic. A

534.232 : 621.395.614

182. A miniature piezoelectric microphone. J. MEDILL. *J. Acoust. Soc. Amer.*, **25**, 864–6 (*Sept.*, 1953).

A new Rochelle salt microphone has been developed for use as a secondary standard in production testing, sound level measurements, high quality transmission of sound, and similar applications. The diameter of the new microphone ($1\frac{1}{8}$ inch) is half the diameter of similar units in current use. Frequency response, directional characteristics, and moisture protection have been improved without a significant loss in sensitivity. A.

534.241

183. Incomplete analogy of the characteristic electrical and acoustic impedances and consequences relative to echo in stratified continuous media. G. ECKART AND P. LIÉNARD. *Acustica*, **2**, *No.* 4, 157–61 (1952) *In French.*

The characteristic acoustic impedance of a medium is defined by analogy with the corresponding quantity for electric waves. In the latter case, there is no internal reflection in a medium continuously stratified provided the characteristic impedance remains constant, but this is not true for sound waves, so that a stratified atmosphere should reflect sound and produce echoes under all circumstances. A.

534.26

184. The concept of radiation scattering and its application to reinforced cylindrical shells. M. C. JUNGER. *J. Acoust. Soc. Amer.*, **25**, 899–903 (*Sept.*, 1953).

Presents an approach which permits the analysis of elastic scatterers embodying complicated structural characteristics. Such problems cannot be investigated by means of the methods previously applied to the study of the scattering action of simple elastic bodies. The scattered wave pressure produced by elastic scatterers may be expressed as the sum of two terms, one representing "rigid body scattering," i.e. the scattering which would exist if the scatterer were rigid and immobile, the other representing "radiation

scattering," which is associated with the sound radiated by the scatterer vibrating under the effect of the incident wave pressure. These two terms are derived here for three important cases. The problem is now reduced to one in elasticity, specifically to the problem of solving the equations of motion of the elastic system for its forced response. The scattering pattern can then be computed. This procedure is applied to a scatterer in the form of a cylindrical shell reinforced with regularly spaced septa. A.

534.26

185. Discussion of the paper by C. Eckart on sea surface scattering. D. MINTZER. Letter in *J. Acoust. Soc. Amer.*, **25**, 1015 (*Sept.*, 1953).

See Abstr. 5348 (1953). In evaluating Helmholtz's theorem for the sound scattered from a rough surface, Eckart assumes the same boundary conditions on the pressure as in the plane surface case. In this note a correction term is found for the boundary condition on the normal derivative of the pressure in order to obtain the conditions under which Eckart's approximation is valid. It is found that Eckart's long-wave results are valid only for sound wavelengths small compared with water wavelengths, or for grazing incidence and non-grazing observation. A.

534.321.9

186. Some applications of ultrasonics. A. GIACOMINI. *Nuovo Cimento*, **9** (*Suppl. No.* 2) 119–50 (1952) *In Italian.*

A summary of methods of producing ultrasonic vibrations is followed by descriptions of many uses. These include medical apparatus, echo-sounders, soldering-irons, apparatus for removing dust particles from flue gases, etc. An extensive bibliography is included. V. G. WELSBY

534.321.9 : 541.127

On the use of ultrasonic absorption for the determination of very rapid reaction rates at equilibrium. *See Abstr.* 834

534.321.9 : 541.127

Relationships between kinetics and acoustic phenomena in equilibrium systems. *See Abstr.* 835

534.321.9 : 578.084

On ultrasonic pictures of the human skull. *See Abstr.* 931

534.373

187. Magnetic damping of acoustic waves in conducting media. E. T. KORNHAUSER. Letter in *J. Acoust. Soc. Amer.*, **25**, 1011–12 (*Sept.*, 1953).

The attenuation of a plane acoustic wave in a conducting medium caused by the ohmic losses of magnetically induced currents is calculated under the assumption that the acoustic wave is unperturbed by the magnetic field. The resulting attenuation constant is independent of frequency. Consideration is given to the attenuation due to this cause in conducting liquids (water and mercury), and to the case of pure longitudinal waves in solids (avoiding ferromagnetic materials). In copper, for example, the attenuation in a field of 2 nepers/metre should be about 3·5 nepers/metre. No data is available to check this deduction. A. B. WOOD

534.522.1

188. Ultrasonic grating remaining after stopping the supersonic waves. II. A. CARRELLI AND F. PORRECA. Letter in *Nuovo Cimento*, **10**, 98–102 (*Jan.*, 1953).

Further details are given of work previously reported [Abstr. 3404 (1952)], with colloidal solutions of starch in water. The experimental technique is described, further results are given for a variety of solutions and the mechanism of the effect is discussed. G. F. HODSMAN

534.7 : 612.85

Physiological acoustics. Hearing. *See Abstr.* 952–4

534.78

189. A study of the building blocks in speech. C. M. HARRIS. *J. Acoust. Soc. Amer.*, **25**, 962–9 (*Sept.*, 1953).

Identification of the information-bearing elements of speech is important in applying recent thinking on information theory to speech communication. One way to study this problem is to select groups of building blocks and use them to form standardized speech which then may be evaluated; a method having the advantage of simplicity is described. Individual recordings of the building blocks were made on magnetic tape and then various pieces of tape were joined together to form words. Experiments indicated that speech based upon one building block for each vowel and consonant not only sounds unnatural but is mostly unintelligible because the influences on vowel and consonants are missing which ordinarily occur between adjacent speech sounds. To synthesize speech with reasonable naturalness, the influence factor should be included. Here these influences can be approximated by employing more than one building block to represent each linguistic element and by selecting these blocks properly, taking into account the spectral characteristics of adjacent sounds so as to approximate the time pattern of the formant structure occurring in ordinary speech. There is no *a priori* method of determining how many building blocks are required to produce intelligible standardized speech. This can only be determined from experiments involving listening tests. Such tests are described. A.

534.78

190. A speech synthesizer. C. M. HARRIS. *J. Acoust. Soc. Amer.*, **25**, 970–5 (*Sept.*, 1953).

"Standardized speech" constructed from building blocks called speech modules was described in the preceding abstract. An electromagnetic device, a "speech module synthesizer," is described here which performs the synthesis automatically. When buttons on a keyboard are pressed, a sequence of corresponding speech modules are automatically recorded on tape exactly in tandem. The modules are selected from a group "stored" on a rotating magnetic drum. The pressing of a button causes an electrical signal corresponding to a module to be reproduced—the electrical switching is so arranged that only one complete module is reproduced for a single button-pressing. This electrical signal is amplified, biased, and then fed into a constantly rotating head which

makes contact with stationary magnetic tape and records the signal on it. A 10 kc/s signal superposed on each stored speech module controls an electromagnetic clutch which (*a*) measures the length of the recording accurately, and (*b*) advances the tape at the completion of the recording by the correct amount so that the next recording forms a connected sequence with it. The same module may be used any number of times and in combination with different stored modules, thereby introducing wider experimental control in standardized speech studies. The principle of this type of device could be applied to other classes of problems involving communication of information, as the conversion into speech of typing or of electronically-read printed matter. A.

534.78

191. Influence of force of articulation of consonants on vowel duration. S. Belasco. Letter in *J. Acoust. Soc. Amer.*, **25**, 1015–16 (*Sept.*, 1953).

Experimental evidence shows that, for a given intensity, on the whole more effort is needed to pronounce consonants than vowels. When the articulatory effort is normal, as in conversation, the decibel values of vowels are greater than that for consonants. P. C. Delattre (1941) has devised a practical method to determine objectively the "force of articulation" of consonants, the experiments being performed with French sounds. It was found that the duration of the vowel sound varied inversely as the degree of physiological energy required to pronounce the consonant. The anticipation of a consonant requiring a "strong" force of articulation will tend to shorten the preceding vowel since more of the total energy needed to pronounce the syllable is concentrated in the consonant. These conclusions are confirmed in a study of American–English vowels, nonsense syllables preceded and followed by different consonant pairs. [See Abstr. 2299 (1953).] A. B. Wood

534.793

192. A probe tube method for the transfer of threshold standards between audiometer earphones. E. L. R. Corliss and M. D. Burkhard. *J. Acoust. Soc. Amer.*, **25**, 990–3 (*Sept.*, 1953).

To establish threshold standards for various types of earphones, from a set of threshold standards that has been determined for one particular type of earphone by a hearing survey, an empirical relationship must be found giving the sound pressures in the calibrating coupler corresponding to equal sound pressures in the ear. This has previously been accomplished by means of loudness balancing between earphones. The method described in this paper makes use of a direct probe measurement of the sound pressure developed by an earphone at the entrance to the ear canal. The experimental process is described and the results of tests to establish the equivalence of the probe method and loudness-balancing are given. In addition, several of the conditions under which loudness-balancing is carried out were investigated by the probe method. Equal loudness sensation was found to correspond to equal sound pressures at the ear, within the limits of experimental error. A.

534.835

193. Theory of tapping sounds on flooring with floating floor. L. Cremer. *Acustica*, **2**, *No.* 4, 167–78 (1952) *In German.*

A floor and its covering are considered as an infinite isotropic plate in which cylindrical flexural waves are excited by the blow of a hammer. The elastic layer is considered as having springiness without side coupling. In the common mats made of glass or slag wool the spring is provided by the enclosed air. The spectrum of the sound excited by a blow on the bare floor is first calculated, (1). When the floating floor is struck bending waves of two types are produced which at high frequencies approach those proper to the individual plates. As in the main floor the type of the greatest wavelength is greater and better radiated than the other type, it is possible to compare its spectrum with that of (1) and deduce the improvement ΔL. Below the frequency at which the inertia resistance of the impinging mass ($i\omega m_0$) exceeds the driving point impedance Z_{01} of the free floating floor and above the natural frequency $f_1 = \frac{1}{2\pi}\sqrt{K/dm_1}$, of the floating floor on the layer of air, the approximate formula $\Delta L = 40 \log (f/f_1)$ holds. Neither the impact mass nor the properties of the main floor nor the flexural stiffness of the floating floor come into the final formula. Increasing the mass of the floating floor or the air space between the two floors would produce improvement, as was to be expected. Only interleaves possessing the compressibility of air can produce improvement over the whole gamut. A.

534.843

194. Reverberation tests with directive sources and receivers. E. Meyer and H. G. Diestel. *Acustica*, **2**, *No.* 4, 161–6 (1952) *In German.*

Using strongly directive sources and receivers, the natural vibrations of the interior of a quadrilateral hall were excited and picked-up. The material whose absorption was to be measured covered one side wall completely. Correct results, in a qualitative sense, were obtained at grazing incidence. The values obtained for normal incidence are independent of the wall surface on which the material is fixed and they agree with values obtained in Kundt's tube. The comparison was made for three materials in the range 500–1000 c/s. Some measurements in the usual manner of the factors for diffuse sound incidence were also obtained for comparison. A.

534.845

195. Absorption of structure-borne sound in building materials without and with sand-filled cavities. W. Kuhl and H. Kaiser. *Acustica*, **2**, *No.* 4, 179–88 (1952).

The loss factor of bricks and reinforced concrete has been measured as function of frequency and vibration amplitude. The absorption of flexural waves on walls, computed according to the results of these measurements, is 20 to 100 times smaller than the actual absorption of structure-borne sound in buildings, the latter being of the order of 1 to 3 db/m. This absorption has been measured by means of piezoelectric transmitters and pick-ups for structure-borne sound in the frequency-range 150 to 3000 c/s.

Using hollow stones filled with sand or other granular substance for walls and floors, this absorption increased by 4 to 6 db/m for middle and high frequencies. This additional damping begins at low frequencies if the cavities are large, if the granular substance has sharp edges, or if a mixture of a hard with a soft substance is used. The acoustic impedance of a closed volume of sand has been measured by means of a vibrometer in order to give a physical explanation of the sand damping. In addition, the damping of short beams with filled cavities of different sizes and the absorption at long walls with filled cavities have been investigated, the results being in good agreement with each other. A.

534.846

196. Subjective comparison of concert halls. T. SOMERVILLE. *B.B.C. Quart.*, **8**, *No.* 2, 125–8 (1953).

The same music was performed in seven different concert halls by the Hallé Orchestra conducted by Sir John Barbirolli, and recorded by the B.B.C. Research Department. An omni-directional microphone was used in a position to give a realistic rendering of the acoustics of the concert hall. Excerpts of about 1½ min. length from each recording were presented to listeners (experienced musicians and other observers) in an order unknown to them, and they were asked to give opinions under three headings, (1) which hall was preferred for tonal quality, (2) in which hall was it easiest to hear the majority of the instruments (definition), and (3) overall preference. Analysis of the results showed the advisability of dividing the subjects into groups. It is disappointing to note that the general public is quite unable to produce significant results; the skilled listeners must necessarily form a small percentage of any concert audience. A. B. WOOD

534.846

197. Measurements of the acoustical properties of two Roman basilicas. A. C. RAES AND G. G. SACERDOTE. *J. Acoust. Soc. Amer.*, **25**, 954–61 (*Sept.*, 1953).

Reverberation times, pressure decay, and echo patterns were experimentally determined. Some conclusions are presented on the application of classical formulae to very large halls and on the influence of architectural elements, especially the usefulness of columns. A.

534.85 : 621.395.623

198. The lateral mechanical impedance of phonograph pickups. I. J. G. WOODWARD AND J. B. HALTER. *Audio Engng*, **37**, 19–20, 52–4 (*June*, 1953).

Measurement of the impedance, hitherto difficult, is important in the case of the new light-weight pick-ups. The device used is a flat steel reed 0·01 in. thick which acts as the armature of a balanced electromagnetic driving system. One end is fixed; the upper end is bent over to provide a small platform in which V-grooves have been cut. The stylus of the pick-up under test, supported from its tone arm, is set in one of these grooves. Excitation of the driving coil causes flexural vibration of the reed and forces the stylus to move with it. A small capacitance pick-up electrode, situated near the top of the reed, measures the phase and amplitude of the reed motion. Measurements are taken with the reed both loaded with the stylus and unloaded. If then the mechanical impedance of the reed itself is measured with known mechanical loads, the mechanical impedance of the pick-up, referred to the stylus point, can be evaluated. Four such vibrators cover the frequency range 30–10 000 c/s. Curves of resistance and reactance components of the impedance of a crystal pick-up are shown and compared with the response characteristic. The operation of such a pick-up is explained in detail and the equivalent circuit shown. The impedance measurements are accurate to within ±15%. H. G. M. SPRATT(R)

534.861

199. The evaluation of the directional characteristics of sound transmitters and receivers. N. MAYER. *Funk u. Ton*, **7**, 398–404 (*Aug.*, 1953) *In German.*

The sound distribution in reverberant rooms is influenced by the directional characteristics of the sound transmitter, and the sound picked up by the microphone depends also on its directional properties. The author discusses the relative effects of direct and reflected sound in relation to the directional properties of the transmitter and receiver, and shows how to determine their "direction factors." A. B. WOOD

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535.14 : 537.39

200. The quantum radiation of a given current. H. KOPPE. *Amer. J. Phys.*, **21**, 548–50 (*Oct.*, 1953).

A new treatment is given of the emission of light quanta by an electrical current. It works with the Heisenberg representation, and might be suitable for teaching purposes. A.

535.23

201. Use of wave number in radiation formulas. M. EPPLEY AND A. R. KAROLI. *J. Opt. Soc. Amer.*, **43**, 957–9 (*Nov.*, 1953).

A brief discussion showing the significance of substituting wave number for wavelength in the radiation formulae is presented. Expressions for the corollaries of the Wien displacement law are given as well as energy curves based on the Planck equation. A straight line relationship is shown to exist between temperature and wave number at maximum energy. An appendix contains a bibliography on blackbody radiation since 1930. A.

535.24 : 628.9

202. Proposed usage of the words "luminance" and "helios." G. A. FRY. *Illum. Engng*, **48**, 406–10 (*Aug.*, 1953).

Discusses the relation between flux density per unit solid angle emitted from a surface in a given direction and the corresponding quantity for the flux arriving at a surface, and proposes that the former should be called luminance and the latter helios (unit, blondel). The definition of reflection factor is also considered. J. W. T. WALSH

535.242 : 535.371

203. A sensitive photometer using modulated light and its application in a uranium fluorimeter. C. D. FLORIDA AND C. N. DAVEY. *J. sci. Instrum.*, **30**, 409–12 (*Nov.*, 1953).

A photometer with a sensitivity of about 10^{-10} lumens is described. This instrument has been

incorporated in a fluorimeter for the determination of very small quantities of uranium: this fluorimeter is also described, and test results are quoted which show that an average instrument has a sensitivity permitting about 5×10^{-10} g of uranium to be measured. A.

535.244 : 628.972

204. Light from a spherical globe. G. R. SHUCK. Letter in *J. Opt. Soc. Amer.*, **43**, 923 (*Oct.*, 1953).

Derives the expression for the light transmitted through a diffusing sphere and shows how this varies with the transmission factor when the absorption factor is kept constant at 0·05. J. W. T. WALSH

535.249 : 522.615 : 621.375.2.029.5/.6 : 621.383

205. Study of high-frequency fluctuations from light sources using phototubes and tuned radio-frequency amplifiers. K. LANDECKER AND B. J. ROBINSON. *Proc. Phys. Soc.* [*London*] *B*, **66**, 737–42 (*Sept.*, 1953).

Phototubes have been used in conjunction with tuned radio-frequency amplifiers to study light fluctuations from discharge tubes and from the sun (sun spots) up to frequencies of 95 Mc/s. In particular the spatial distribution of some types of oscillations along the axis of discharges in helium and mercury vapour have been obtained but so far no fluctuations of light from the "quiet" sun have been observed. A.

535.3

206. Light modulation through openings in parallel-moving diaphragms. G. C. MÖNCH. *Optik*, **10**, *No.* 7, 350–61 (1953) *In German.*

Amplitude modulation of a light beam is obtained by moving an occluding diaphragm over illuminated openings. The amplitude variation is calculated from the geometry of the diaphragm and openings for a number of special shapes. Practical means of moving the diaphragm are discussed and some uses of the method briefly given. R. W. FISH

535.31

207. The torsion of a luminous trajectory in a continuous isotropic refracting medium. A. MARUSSI. *Atti Fond. Ronchi*, **8**, 104–8 (*March–April*, 1953) *In Italian.*

Such torsion depends upon the geodetic torsion of the surfaces of equal refractive index in the direction determined by the osculating plane of the path, and upon the curvature vector of the orthogonal trajectories to such surfaces. A.

535.31

208. Fourier treatment of optical processes. O. H. SCHADE. Letter in *J. Opt. Soc. Amer.*, **43**, 704–5 (*Aug.*, 1953).

The author comments upon the method of Elias [Abstr. 3426 (1952)] which he has previously applied to the evaluation of television and photographic systems. Some of the practical difficulties are discussed. R. W. FISH

535.31 : 535.8

209. Analysis of the aberration contributions of single surfaces and aberration types for meridian rays of optical systems into intrinsic and induced terms. A. THOMESCHEIT. *Optik*, **10**, *No.* 7, 339–49 (1953) *In German.*

Previously (1942) it was shown how to effect the analysis into total surface contributions, using fictitious aberration-free rays. Again using ray-tracing results, it is proposed to resolve the contributions of single surfaces into intrinsic and a group of induced aberrations. For the vth surface of a system there are 2^{v-1} sub-contributions to the induced aberration. A scheme is set out symbolically, and its applications are mentioned. H. H. HOPKINS

535.31 : 535.8

210. On the calculation of the contribution of single surfaces to the total aberration of an optical system. F. WEIDERT. *Optik*, **10**, *No.* 8, 375–88 (1953) *In German.*

A number of earlier methods, including Kerber's, are discussed critically. It is concluded that these methods only resolve the total aberration into surface contributions which are approximate. In the present method an exact longitudinal magnification formula is obtained by means of which the problem is solved exactly for axial spherical aberration. Results using the different methods are compared in the case of an $f/4\cdot5$ triplet. H. H. HOPKINS

535.312

211. Design of systems with double reflection. C. MORAIS. *An. Real. Soc. Españ. Fis. Quim.*, **49 (A)**, 153–72 (*May–June*, 1953) *In Spanish.*

This is divided into two parts: in the first, taking the reflective system as known, the orientation of the image with regard to a fixed object is studied. In the second, the characteristics are determined of the double reflection system capable of producing a set orientation of the image with regard to the same object. A.

535.317

212. Note on "A general contribution formula for tangential rays." J. L. RAYCES. Letter in *J. Opt. Soc. Amer.*, **43**, 705–6 (*Aug.*, 1953).

An exact contribution formula is derived for the astigmatism of a narrow pencil of rays of finite inclination to the optical axis and it is shown to be a special case of the general formula of Delano [Abstr. 8771 (1952)]. R. W. FISH

535.317.4 : 535.824.2

213. A study of the combined effects of aberrations and a central obstruction of the pupil on the contrast of an optical image. Application to microscope objectives using mirrors. III–IV. W. H. STEEL. *Rev. Opt.*, **32**, 269–306 (*May*, 1953) *In French.*

III. Previous results [Abstr. 5379 (1953)] are used to form tolerances for the aberrations and obstruction ratio. The choice of test object is briefly discussed.

IV. Microscope objectives consisting of 2, 3 or 4 mirrors are described and the residual aberrations calculated. 41 References. R. W. FISH

535.317.6

214. Differential formulae concerning the calculation of central optical systems. E. SPARATORE. *Atti Fond. Ronchi*, **8**, 192–202 (*May–June*, 1953) *In Italian.*

It is possible by means of a purely algebraic method due to C. Morais to calculate the path of a meridional ray through an optical system, which will be called the initial system. Some formulae are derived for evaluating the variations of the parameters of the

inal ray due to infinitesimal variations of the constructive elements of the system. The knowledge of the partial derivatives is important in the stage of the fine corrections. A.

535.317.6

215. Some simplifications of 3rd order formulae for the calculation of thin systems. M. CORRIAS. *Atti Fond. Ronchi*, **8**, 270–3 (*July–Aug.*, 1953) *In Italian.*

These new formulae allow a considerable saving of time compared with the usual methods, especially in the case of the cemented objectives. A.

535.322.4

216. A simple recording differential refractometer. G. H. F. SEIFLOW. *J. sci. Instrum.*, **30**, 407–8 (*Nov.*, 1953).

A recording refractometer is described, in which a beam of light, deviated in passing through the effluent from a chromatographic column, falls on a split photocell connected to a galvanometer. The deflection of a second galvanometer in a circuit containing a recording milliammeter is manually controlled to be always equal to that of the first galvanometer. A.

535.322.4 : 535.414

217. A modified Michelson refractometer. P. G. GUEST AND W. M. SIMMONS. *J. sci. Instrum.*, **30**, 361–2 (*Oct.*, 1953).

One of the beams in a Michelson interferometer is deviated through a right angle so that the two beams are parallel to one another. Fringes of the Fresnel type are employed, and a fiduciary system is used as the standard of reference. An accuracy in setting of better than 1/60th of a fringe is obtained by visual observation; this accuracy can be considerably improved if photoelectric detectors are used. A.

535.323

218. The optical properties of titanium dioxide. T. RADHAKRISHNAN. *Proc. Indian Acad. Sci. A*, **35**, 117–25 (*March*, 1952).

Dispersion formulae valid in the visible region are offered for rutile, anatase and brookite. These incorporate a characteristic frequency at 2870 Å in all the cases. The value of dn/dt in the three crystals are explained by large transfers of transition probability and moderate shifts towards larger wavelengths of this frequency as the temperature is raised. In addition, a calculation is made of the refractive indices and birefringence of rutile on the basis of Bragg's theory and the results are in good accord with the observed data. A.

535.323

219. Refractive index determination for anisotropic crystals. C. W. BUNN; A. L. MACKAY. Letters in *Brit. J. appl. Phys.*, **4**, 284 (*Sept.*, 1953).

Ambronn's method, recently revived [Abstr. 6595 (1953)] is shown to be fallacious. A. L. MACKAY

535.327

220. Further studies on the temperature variation of the refractive index of crystals. T. RADHAKRISHNAN. *Proc. Indian Acad. Sci. A*, **33**, 22–34 (*Jan.*, 1951).

For previous work see Abstr. 934 (1951). The temperature coefficients of refraction of lithium fluoride, fluorspar, magnesia and quartz have been determined interferometrically for wavelengths between $\lambda 2500$ and $\lambda 6000$, from room temperature to 400°C. The values have been utilized to calculate the temperature dependence of the ultraviolet frequencies, using Ramachandran's theory [Abstr. 2479 (1947)] of thermo-optic behaviour. The theory is found to account successfully for the variation of dn/dt with wavelength and temperature. Similar results have been obtained in the visible region alone for the three refractive indices of barite. A.

535.327

221. The thermo-optic behaviour of quartz. A. K. RAMDAS. *Proc. Indian Acad. Sci. A*, **35**, 89–98 (*Feb.*, 1952).

The temperature variation of the refractive indices of α-quartz contains a positive part, though it is completely submerged by the predominant negative part due to the thermal expansion. At the α-β transition temperature of 573°C, the structural changes represented by the α-β transformation cause a change in a direction opposite to that of the density change, i.e. an increase in the refractive indices. The rate of change of the electronic dispersion wavelengths decreases with decreasing temperatures tending to zero at very low temperatures. The thermo-optic behaviour of quartz and vitreous silica bear a close resemblance, the difference in the two cases being due to the difference in the thermal expansions. A.

535.33 : 551.594.5

The intensities of atomic and molecular features in the auroral spectrum. *See Abstr.* 924

535.33.07

222. On the "minimum ray concept" with spectrographs. H. WOLTER. *Z. Phys.*, **135**, *No.* 5, 531–40 (1953) *In German.*

Principles previously described [Abstr. 232 (1951)] may be applied to a spectrograph by placing in front of the camera lens two thin transparent plates inclined at a small angle to one another, so that there is a phase difference of $\theta = 180°$ between the two halves of the wavefront. The result is to produce a narrow intensity minimum at the centre of a spectral line, permitting very exact measurement of its position. Equations are deduced from which it is shown that with a grating θ is practically constant over a large spectrum range; with a particular prism spectrograph the variation of θ is only $\pm 14°$ over the visible spectrum, and this has a negligible effect.

G. F. LOTHIAN

535.33.07

223. A new high-speed recording technique for use with infra-red spectroscopes. A. U. MOMIN. *Proc. Indian Acad. Sci. A*, **37**, 248–53 (*Feb.*, 1953).

The 10 c/s signal from the thermopile is amplified and the output fed to the X-plates of a cathode-ray tube. A photographic film moving in the Y direction synchronously with the wavelength changing mechanism gives a record showing signal against wavelength. G. F. LOTHIAN

535.33.07

224. An evaluation of two simple methods for calibrating wavelength and absorbance scales of modern spectrophotometers. L. J. HEIDT AND D. E. BOSLEY. *J. Opt. Soc. Amer.*, **43**, 760–6 (*Sept.*, 1953).

Two simple methods have been evaluated for calibrating wavelength and absorbance scales of

modern spectrophotometers, namely, a method for wavelength scales which is based on the locations of the maxima and minima of the absorbance wave of a pair of transparent closely-spaced parallel plates, and a method for absorbance scales which is based on the absorbances of properly oriented screens of square-woven single strands of brass wire. The evaluations were carried out by means of a Beckman DU, a Cary and a Hardy-GE spectrophotometer. It is hoped that the simple, convenient methods will encourage more frequent calibration of spectrophotometers, especially when the wavelengths and values of absorbance extremes are of importance. A.

535.33.07

225. An attachment to permit the examination of liquid films by a Beckman Model DU spectrophotometer. H. G. McAdie and R. V. V. Nicholls. *J. Opt. Soc. Amer.*, **43**, 767–8 (*Sept.*, 1953).

A simple modification is described permitting the examination of liquid films cast on silica plates. The performance of the instrument is affected to the extent of a loss of 5 mμ at the extreme ultraviolet end of the instrument. A.

535.33.07

226. A high-speed cathode-ray indicating spectrophotometer. R. C. Beitz. *J. Opt. Soc. Amer.*, **43**, 773–6 (*Sept.*, 1953).

A new instrument for displaying spectrophotometric curves almost instantly on a cathode-ray tube is described. The curves are presented on a linear per cent transmission scale and a linear wavelength scale. The instrument includes a conventional spectrometer, light source and photo-multiplier combined with an optical means of correcting for the emission characteristics of the source and the spectral sensitivity of the photo-cathode. A novel sweep circuit, not an oscillator, is utilized to cause the cathode-ray tube spot to move non-linearly with respect to time so as to compensate for the non-linear dispersion of the optical system and plot the spectra on a linear wavelength scale. Spectra are displayed at the rate of 60 per sec, with a scanning time of approximately 1/180 sec per spectrum. A synchronous mirror drive in an inverse feedback system incorporating the non-linear sweep circuit of the indicator is used to produce these results. Spectrophotometric curves may be viewed directly or recorded photographically. Means are described for obtaining diffuse reflectance curves as well as emission spectra with the same instrument. Photographic records of spectra of various types taken with this instrument are shown, and the basic design considerations are briefly discussed. A.

535.33.07

227. Precision measurement of wavelengths with echelle spectrographs. G. R. Harrison, S. P. Davis and H. J. Robertson. *J. Opt. Soc. Amer.*, **43**, 853–61 (*Oct.*, 1953).

Echelles of the type now produced by the Bausch and Lomb Optical Company lie intermediate in dispersive properties between ordinary diffraction gratings and such interferometers as the Fabry–Pérot etalon. When crossed with a concave grating in a stigmatic mount of the type described in Abstr. 109 (1953), an echelle might be expected to give wavelength precision between the approximately one part in 10^6 of which the grating is capable and the one part in 25×10^6 of the etalon. Precision to about 1 part in 5×10^6 was found attainable with the echelle. Identification of the order of interference m of any cycle on an echellegram can be made quickly and exactly by use of a standard plate or scale, which can be marked uniquely after photography of two or three known lines. A horizontal fiducial line of constant $m\lambda_0$ is recorded on the spectrogram by reflecting light from a mirror which can be swung into position in front of the echelle. The exact $m\lambda_0$ value for the plate is determined from the two or three standard lines photographed on it. Wavelength reduction is most conveniently made in terms of $m\lambda$, using the $m\lambda_0$ line as a reference. The vertical $m\lambda$ dispersion is first assumed constant over the entire plate, and an approximate $m\lambda$ value is determined for each line in terms of its distance l from $m\lambda_0$. A small correction ε is then added for each line, values of ε for the entire fixed focal surface having been determined in advance with some complex spectrum having many known lines, such as thorium. Values of ε are found to not exceed 0·050 m order-ångströms with the instrument. This range includes empirical corrections for error of coincidence, non-uniformity of dispersion along a cycle, variable magnification of the spectrograph and all other deviations from vertical linearity or horizontal constancy of $m\lambda$. On division by three-figure integral values of m, wavelengths can be obtained to within about 0·001 Å throughout the visible and ultraviolet spectrum, with little added complexity beyond that required for reducing grating spectrograms, and with greater precision, compactness and spectrum coverage on a single plate. A discussion of the so-called "error of coincidence" is included, as this phenomenon, which has been principally of historical importance since the early days of spectroscopy, now affects the accuracy attainable with a single fiducial line and two or three Hg 198 lines, when substituted for the large number of standard lines needed for precision wavelength determinations with concave gratings. A.

535.33.07

228. A comparative survey of spectrophotometers in the 210–760 mμ region. W. R. Brode, J. H. Gould, J. E. Whitney and G. M. Wyman. *J. Opt. Soc. Amer.*, **43**, 862–5 (*Oct.*, 1953).

The absorption spectra of an alkaline solution of potassium chromate and a sample of "Tropex" glass were determined in fifteen co-operating laboratories using the Cary and Beckman DU spectrophotometers under comparable conditions. Simple statistical calculations on the results indicate satisfactory agreement among the several instruments of the same manufacture and also between the two types of spectrophotometers. A.

535.33.07

229. A projector-comparator for examining spectrographic plates. J. C. North. *J. sci. Instrum.*, **30**, 366–9 (*Oct.*, 1953).

A relatively compact bench-mounted projector-comparator is described. With it any section of one 10×4 in. spectrographic plate may be compared with any section of another. Thus it is possible to compare

plates taken with different settings of a large spectrograph. The approximate area of the main plate projected, with a magnification of ×20, is 1×¾ in., while that of the comparison plate is 1×¼ in., the line of contact between the two projected areas being near the front of the 20 in. square opaque screen. Provision is made to adjust the magnification of the comparison plate to between ×19 and ×21. A marker is fitted for the main plate. A.

535.33.07

230. A new system for the elimination of scattered light effects in spectrophotometers. V. J. Hammond and W. C. Price. Letter in *J. Opt. Soc. Amer.*, **43**, 924 (*Oct.*, 1953).

The Littrow mirror is rocked about a horizontal axis at a frequency equal to that of a tuned amplifier following the detector. G. F. LOTHIAN

535.33.07

231. The elimination of atmospheric water vapor absorption in the Perkin–Elmer infrared spectrometer. R. D. B. Fraser. Letter in *J. Opt. Soc. Amer.*, **43**, 929 (*Oct.*, 1953).

Exposed path length is reduced by focusing source on the specimen. Dried air is circulated in the enclosures. G. F. LOTHIAN

535.33.07

232. The calibration of infrared prism spectrometers. A. R. Downie, M. C. Magoon, T. Purcell and B. Crawford, Jr. *J. Opt. Soc. Amer.*, **43**, 941–51 (*Nov.*, 1953).

A search has been made for sharp absorption maxima suitable for calibrating infrared prism spectrometers at closely spaced intervals. A set of such points, corrected and tested, is presented together with traces showing the appearance of the calibration spectra, and the conditions for reproducing them. Suitable points are included for SiO_2, LiF, CaF_2, NaCl, KBr and CsBr prisms. A.

535.33.07

233. The effect of a helium atmosphere on the Beckman infrared spectrophotometer. W. R. Brode, J. H. Gould and G. M. Wyman. *J. Opt. Soc. Amer.*, **43**, 969–70 (*Nov.*, 1953).

Displacement of the air from the optical path of a Beckman IR2T spectrophotometer by helium was found to result in an increase in the current of the Nernst glower and a displacement of the wavelength calibration of the instrument. The former was attributable to the greater thermal conductivity of helium, while the latter resulted from its lower index of refraction. It was found possible to evaluate the refractive index of other gases from the observed displacements in the wavelength calibration of the instrument. A.

535.33.07 : 535.339–15

234. A monochromator system with constant energy output in the 0·7–7 μ spectral region. D. G. Avery and P. H. Hammond. *J. sci. Instrum.*, **30**, 400–1 (*Nov.*, 1953).

The apparatus described is primarily intended for the rapid measurement of the spectral response of photocells. Radiation emerging from an infrared monochromator is split into two beams. One is used in conjunction with a radiation thermocouple to control the energy output from the tungsten filament used as source, providing a constant energy output from the monochromator, independent of wavelength. The other beam, constant in intensity, is used for the spectral response measurements. A.

535.33.07 : 535.822.9

235. A 0·8 N.A. reflecting microscope for infrared absorption measurements. R. D. B. Fraser. Letter in *J. Opt. Soc. Amer.*, **43**, 929–30 (*Oct.*, 1953).

The microscope uses spherical mirrors only. G. F. LOTHIAN

535.33.07 : 545.82

236. A new approach to direct reading spectrochemical analysis. R. K. Brehm and V. A. Fassel. *J. Opt. Soc. Amer.*, **43**, 886–9 (*Oct.*, 1953).

A preliminary note on the design and performance of a new type of instrument is presented. A single multiplier phototube is used in combination with a rapid-scanning spectrometer. As the spectral lines cross the single exit slit, voltage pulses are generated by the phototube and are panoramically presented on an oscillosope whose time-base is synchronized with the spectrum scan. The pulse heights are measured by converting them to "bursts" of constant amplitude pulses whose number is proportional to the magnitude of the original spectral line pulse. This is accomplished by means of a cathode-ray tube, a "comb-grid," and a secondary multiplier phototube. The pulse bursts corresponding to the lines whose intensity is of interest are separated by means of electronic gates. High-speed scalers and mechanical registers indicate the time integrals of the spectral line intensities. Intensity ratios are automatically computed after the exposure and recorded on a variable span strip chart recorder, which may be empirically calibrated to read directly in percentage. Preliminary data indicate that a precision of analysis of ±1% can be achieved. A.

535.33.07 : 545.82

237. Small-infrared spectrometer analyzer for chemical process streams. L. W. Herscher and N. Wright. *J. Opt. Soc. Amer.*, **43**, 980–3 (*Nov.*, 1953).

Multicomponent plant streams requiring continuous analysis are sometimes encountered which for various reasons cannot be handled by the non-dispersive analyser. In such cases the laboratory-type infrared spectrometer may be used, but this requires air-conditioned space and environmental control often impractical in a plant. This paper describes a small spectrometer, enclosed in an explosion-proof box of internal dimensions, 11 in.×13 in.×7 in., which has successfully solved a difficult plant control problem. Within the box are radiation source, cell for the continuously flowing liquid sample, radiation chopper, and the optical system which employs a 60° NaCl prism with faces 75 mm ×60 mm. A separate box of similar size houses the amplifier. A standard strip-chart recorder and pneumatic controller completes the equipment. Continuous analysis of one of the stream components is used to control a distillation column. A.

535.33.07 : 778.392

238. Spectroscopic intensities and photographic blackening. R. W. NICHOLLS. *J. Opt. Soc. Amer.*, **43**, 882–6 (*Oct.*, 1953).

A method has been devised by which the photographic densities of molecular spectra may be interpreted in terms of excitation conditions in the source, as a preliminary to the more accurate, though tedious, heterochromatic photometric calibration. Though developed primarily for laboratory use, the method would find application in the interpretation of auroral spectra. A.

535.33.07–15

239. Silver chloride beam condensing lens system for micro infrared measurements. D. H. ANDERSON AND O. E. MILLER. *J. Opt. Soc. Amer.*, **43**, 777–9 (*Sept.*, 1953).

Reflecting microscope systems have been used successfully to secure measurements on samples in the microgram range. However, the expense of the optical components and the assembly problems associated with coupling reflecting microscope systems to existing instruments, particularly double-beam spectrophotometers, have limited the applications. The system described here uses relatively inexpensive silver chloride lenses which can be readily fabricated to meet individual instrumental requirements. The reduction in image size so far attained has not been as great as has been reported for reflecting systems, but many problems do not require large reductions of image size. In many cases, samples in the fractional milligram range are available for testing, and such samples can be tested with less elaborate equipment than the reflecting microscope systems. Initially a reduction of about $\frac{1}{3}$ in image size has been secured, which allows about a tenfold reduction in the normal sample size. Other trials have indicated that a reduction of at least $\frac{1}{10}$ in image size should be obtainable. With the Baird double-beam spectrophotometer now in use, samples in the range of 20 to 50 μg can be examined routinely with no change in slit settings or in amplifier gain. The lens unit is easily introduced into the instrument, and all the advantages of double-beam operation are retained. A.

535.33.07–15

240. A simple method of obtaining the infrared spectra of solid organic samples. B. M. MITZNER. Letter in *J. Opt. Soc. Amer.*, **43**, 806 (*Sept.*, 1953).

For stable samples melting below 110°C. The sample is liquified and introduced into the infrared cell. Heating of the cell is contrived by a hot air stream from a hairdrier. C. TURNER

535.33.07–15

241. A simple technique for recovering infrared samples. B. M. MITZNER. Letter in *J. Opt. Soc. Amer.*, **43**, 806–7 (*Sept.*, 1953).

The sample is washed out of the cell with a suitable solvent, introduced by a hypodermic syringe at one end and collected at the other end in a second syringe. C. TURNER

535.33.07–15

242. A double-beam double-pass infrared spectrometer. A. R. H. COLE. Letter in *J. Opt. Soc. Amer.*, **43**, 807–8 (*Sept.*, 1953).

The double-pass system due to Walsh may be applied to a double-beam monochromator, giving increased resolution without the increased atmospheric absorption found with the original system. Some practical details are given. R. W. FISH

535.33.07–15

243. An intensity-compensating system for infrared spectrophotometry. H. M. RICHARDSON, R. G. FOWLER AND M. L. COFFMAN. *J. Opt. Soc. Amer.*, **43**, 873–6 (*Oct.*, 1953).

A novel compensating device for use in infrared spectrophotometry has been designed, constructed, and its properties investigated. The device consists of two sector disks rotated synchronously, with phase control on one disk permitting an absolute variation of the transmission factor of the compensator. No operational tests on an actual spectrophotometer have been made. A.

535.33.07–15

244. Resolving power and noise in infrared spectroscopes. S. BRODERSEN. *J. Opt. Soc. Amer.*, **43**, 877–82 (*Oct.*, 1953).

A review is given of the factors contributing to the noise and to the limitations in resolving power. Their mutual dependence is expressed in simple formulae. The factors contributing to the limitations in resolving power at infinitely narrow slits are discussed in detail. Their sum is approximated by a Gauss curve of width s_0. The finite slit width s_g adds to s_0 giving an effective slit width s_{eff}, where $s_{eff}^2 = s_0^2 + s_g^2$. Expressions are given for the energy from the glower traversing the spectroscope and for the noise generated in the detector amplifier system. From these the signal-to-noise ratio and the relative random errors in D due to noise are expressed in terms of s_g, transmittancy of sample, filter time constant and a few functions characteristic of the spectroscope. Optimal scanning conditions are discussed on this basis. It is shown that s_g in most cases ought to have a magnitude between $s_0/2$ and s_0. A.

535.33.07–15

245. On the fabrication of alkali halide windows. R. RYASON. Letter in *J. Opt. Soc. Amer.*, **43**, 928 (*Oct.*, 1953).

Disks suitable for windows in gas and liquid absorption cells are made by compression of powdered KCl and KBr in a 20-ton hydraulic press. Practical details of the method and sample transmission data are given. R. W. FISH

535.33.07–15

246. Infrared measurements with a cesium iodide prism. N. ACQUISTA AND E. K. PLYLER. *J. Opt. Soc. Amer.*, **43**, 977–9 (*Nov.*, 1953).

A 35° caesium iodide prism was installed in a Perkin–Elmer 12C infrared spectrometer. After the stray radiation had been reduced by filters, it was possible to observe infrared radiation at wavelengths as long as 54 μ. The spectrometer was calibrated by the identification of rotational lines of atmospheric water by using the known grating values. The single-pass and the Walsh double-pass systems were compared and their advantages noted. The transmittances

of crystals of CsBr, TlBr–I, CsI and of films of polystyrene and polyethylene have been measured. In addition, the absorption spectrum of three halomethanes and three halobenzenes has also been observed. Prism spectrometry from 24 to 54 μ with a CsI prism is handled by the same methods as those used with a CsBr prism. The spectra of several molecules are given for the region from 25 to 50 μ. A.

535.33.07–15 : 578.087

247. Goniometric spectrometer for the measurement of diffuse reflectance and transmittance of skin in the infrared spectral region. C. CLARK, R. VINEGAR AND J. D. HARDY. *J. Opt. Soc. Amer.*, **43**, 993–8 (*Nov.*, 1953).

The apparatus consists essentially of a monochrometer and a goniometer arranged in such a way that the material to be studied is illuminated with monochromatic light and the diffuse reflected and transmitted energy is measured by scanning the goniometer about the sample. The advantages of the instrument are (*a*) absolute measurements of total reflectance and transmittance are obtained; and (*b*) the angular distribution of the scattering of the reflected and transmitted energy are determined. A.

535.33.07–31

248. A ratio recording double-beam ultraviolet spectrophotometer. W. H. KING, JR. *J. Opt. Soc. Amer.*, **43**, 866–9 (*Oct.*, 1953).

A single-beam infrared spectrophotometer has been converted to a ratio recording double-beam ultraviolet spectrophotometer. This conversion is simple and inexpensive since only commercially available parts are needed. The instrument uses a single detector and a phase discriminating system to separate the dual beams. The recorder presents the electrical ratio which is drift free. Auxiliary apparatus to correct for difference of spectral response of the two beams is not required since both beams travel over identical optical paths and fall on the same detector. Spectra are presented as per cent transmission *v.* wavelength over the range 215 to 600 mμ. A.

535.33.072 : 545.82

249. Quantitative spectrochemical analysis with the aid of a slitless spectrograph. A. CORNU. *Cahiers de Phys.*, *No.* 44, 74–80 (*July*, 1953) *In French.*

Describes the design and operation of a device to replace the slit in a spectrograph, consisting of a highly polished cylindrical metal (stainless steel) rod of 7 mm diameter, arranged vertically in the place of slit. A source of light illuminating the rod at an acute angle to the collimator axis (usually $\sim 60°$) produces a fine rectilinear image on the axis and a sharply defined spectrum, both the alignment and the definition being practically independent of the position of the source. The width of the reflected image has been deduced geometrically and the results have been checked by experiments. In accordance with the author's summary, further sections of the paper will deal with various applications of the novel spectrograph. F. LACHMAN

535.338 : 537.525.4

Relative time dependence of the emission of line and background from the vacuum spark. *See Abstr.* 489

535.338–15

250. Extension of the second spectrum of zirconium into the infrared. C. C. KIESS. *J. Opt. Soc. Amer.*, **43**, 1024–6 (*Nov.*, 1953).

A recent investigation of the spectrum emitted by condensed spark discharges between metallic zirconium electrodes has revealed about 75 new lines of Zr II in the region between 10 000 Å and 4800 Å. Most of these lines are accounted for as combinations between previously known terms. The remaining lines have led to the discovery of a new term, here designated as $4d^3\,{}^2D$. This new term lies highest among those from the low, even electron configurations $4d^25s$, $4d^3$ and $4d5s^2$ and conforms to theoretical requirements for a ^2D term of its energy and character. It replaces the "doubtful and relatively inconspicuous" term d^2D of the older analysis, which is now rejected as spurious. A.

535.338–15

251. The first spectrum of mercury in the region between 1·3 and 2·0 μ. C. J. HUMPHREYS. *J. Opt. Soc. Amer.*, **43**, 1027–9 (*Nov.*, 1953).

The spectrum has been observed with a high-resolution grating spectrometer employing a lead sulphide detector. A noteworthy feature of the new observations is the essentially complete resolution of the *D-F* multiplets involving both first and second members of *F* series. Such resolution was achieved only with a low-pressure source. All new lines have been classified. A few changes in existing classifications and minor revisions in term values are suggested. A.

535.338–15

252. The magnesium arc spectrum in the near infrared. R. A. FISHER AND F. E. ESHBACH. *J. Opt. Soc. Amer.*, **43**, 1030–2 (*Nov.*, 1953).

Wavelength and intensity measurements on prominent lines of Mg I have been made with a recording spectrograph using arc and hollow cathode sources. New wavelength data indicate some multiplet structure not previously observed and provide new information on certain energy level values. A.

535.338.4

253. On the spectra of the CN^+ and CN molecules. A. E. DOUGLAS AND P. M. ROUTLY. Note in *Astrophys. J.*, **117**, 461–2 (*May*, 1953).

The spectrum of a hollow cathode discharge tube through which was pumped helium with a trace of C_2N_2 gave a large number of unidentified bands in the region 4500–1900 Å. Results of a rotational analysis of some of these are tabulated, and reasons given for attributing them to CN^+. Two new band systems of neutral CN were also found, and many other new bands of which some may be due to CN^+. Further work is in progress. D. L. EDWARDS

535.338.4

254. The rotational structure of the band spectrum of S_2 molecule. I. K. IKENOUE. *J. Phys. Soc. Japan*, **8**, 646–52 (*Sept.–Oct.*, 1953).

The band spectrum of the S_2 molecule has been studied in the region from 3700 Å to 4500 Å. The following values of the rotational constants have been obtained: $B'' = 0{\cdot}2962\ \text{cm}^{-1}$, $\alpha_e'' = 0{\cdot}00163\ \text{cm}^{-1}$,

$D_e'' = -0{\cdot}000023\ cm^{-1}$, $\beta_e'' = -0{\cdot}0000003\ cm^{-1}$, $\gamma'' = -0{\cdot}035\ cm^{-1}$. A.

535.338.4

255. Some remarks concerning Swings' bands and the formation of graphitic dust. S. HAUTECLER AND B. ROSEN. *C.R. Acad. Sci.* [*Paris*] **237,** 794–5 (*Oct.* 12, 1953) *In French.*

Spectra of individual sparklets in a carbon hollow-cathode discharge show mainly C_2, with only weak CH and 4050 Å (Swings) group; the emitter of the latter must be formed by a secondary process. The Swings–Rao bands (3850–3300 Å) appear with 4050 Å, but not those of Merrill–Sanford (5200–4200 Å). The relation between carbon dust and the various bands in astronomical spectra (Mars, variable stars, R Coronae Borealis) is discussed. A. G. GAYDON

535.338.4 : 523.67

256. Observation of the 4050 Å band group in a King furnace. W. B. S. GARTON. Letter in *Proc. Phys. Soc.* [*London*] *A*, **66,** 848–9 (*Sept.*, 1953).

The spectrum of radiation from a King-type vacuum furnace running at a temperature, 2500°c, shows the Swan system of C_2, together with the 5 strongest bands of the 4050 Å group, both in emission. Initially, the pressure of residual gas was $<0{\cdot}05$ mm Hg: with a slow current of H_2 passing through the furnace tube at 5 mm pressure, intensities of both systems remained unchanged. The 4050 Å group appears in cometary spectra, and Douglas [Abstr. 3449 (1952)] suggests linear triatomic carbon as the emitter. [See also Abstr. 6415, 6419, 6436 (1953).] D. R. BARBER

535.338.4–15 : 551.593.9

Spectrum of the night sky in the range, 1·2–2 μ. *See Abstr.* 915

535.338.42 : 539.132

257. The spectrum of nitrogen dioxide in the 1·4–3·4 μ region and the vibrational and rotational constants of the NO_2 molecule. G. E. MOORE. *J. Opt. Soc. Amer.*, **43,** 1045–50 (*Nov.*, 1953).

This has been reinvestigated under high dispersion. The nine bands observed show resolvable rotational structure and the moments of inertia obtained, in conjunction with the large rotational constant from measurements of ν_2 by Wilson and Brown, yield the ground state parameters $r_{N-O} = 1{\cdot}188 \pm 0{\cdot}004$ Å and $<O\text{–}N\text{–}O = 134° 4' \pm 15'$. The set of overtones and combinations observed together with $\nu_2 = 750{\cdot}9\ cm^{-1}$ from Wilson and Brown allow one to determine a complete set of quadratic vibrational interaction constants. The fundamental frequencies of NO_2 are $\nu_1 = 1322{\cdot}5\ cm^{-1}$, $\nu_2 = 750{\cdot}9\ cm^{-1}$, and $\nu_3 = 1616{\cdot}0\ cm^{-1}$. An intensity alternation is observed in type *A* bands as is predicted by theory but which, as far as the authors are aware, has not previously been observed in a similar case. An apparently abnormal interaction, which is not adequately explained, occurs between the vibrational levels $3\nu_3$ and $2\nu_1 + 3\nu_2$ and likewise between $\nu_1 + 3\nu_3$ and $3\nu_1 + 3\nu_2$. A.

535.34–15 : 537.311.33

Optical studies of injected carriers. I. Infrared absorption in germanium. II. Recombination radiation in germanium. *See Abstr.* 453–4

535.34–15 : 537.311.33

Absorption of infrared light by free carriers in germanium. *See Abstr.* 455

535.34–15 : 537.311.33

Infrared absorption in *P*-type germanium. *See Abstr.* 456

535.343–14

258. Broadening of microwave absorption lines due to wall collisions. M. DANOS AND S. GESCHWIND. *Phys. Rev.*, **91,** 1159–62 (*Sept.* 1, 1953).

This is calculated using a method introduced by Johnson and Strandberg [Abstr. 6385 (1952)]. Two types of absorption cell are studied, i.e. infinite plane parallel plates and a circular cylinder, each in a region of uniform microwave field. The usual assumption that the half-power half-width is given by $\Delta\nu = 1/2\pi\tau$, where τ is the mean time between collisions is in good agreement with the detailed calculations of the present work which show that the error in the line width as calculated by the above expression is not larger than 30%. Experimentally observed line widths agree with the predicted values. A.

535.343–14 : 539.133

259. The methyl alcohol molecule and its microwave spectrum. E. V. IVASH AND D. M. DENNISON. *J. chem. Phys.*, **21,** 1804–16 (*Oct.*, 1953).

The theory of hindered rotation in methyl alcohol developed by Burkhard and Dennison [Abstr. 445 (1952)] has been extended to include the second-order Stark effect as well as a detailed discussion of *K* type doubling. It has been applied to an interpretation of the microwave spectrum of normal methanol and of two isotopic molecules, $C^{13}H_3O^{16}H$ and $C^{12}H_3O^{18}H$, recently measured by Hughes, Good, and Coles. A very convincing fit between the predicted and observed lines is obtained which serves to determine many of the molecular constants, as well as providing a substantial number of self-consistency checks. The height of the potential barrier (on the assumption of a sinusoidal potential) is found to be $374{\cdot}8\ cm^{-1}$. The CH distance in the methyl group cannot be obtained with any accuracy from the present data but is consistent with the CH distance in methane, namely, 1·093 Å, and has been taken to have this value. The remaining dimensions are, however, well determined and are: OH distance = 0·937 Å, CO distance = 1·434 Å, COH angle = 105° 56′, HCH angle = 109° 30′. The symmetry axis of the methyl group passes between the H and O of the hydroxyl group and lies at a distance of 0·079 Å from the oxygen. The above values for the barrier height and molecular dimensions do not differ much from those found by Burkhard and Dennison but are believed to be considerably more accurate. Using the molecular constants, the positions of all the observed microwave lines which can be identified have been calculated. In every case the agreement is good. Those discrepancies which do exist are of an order of magnitude which can be ascribed to higher-order effects not included in the present theory. The Stark effect, both first and second order, has been computed for all identified lines. In all but one or two cases the agreement with experiment is found to be very satisfactory. A.

535.343–15

260. Infrared spectra of coal and carbohydrate chars. R. A. Friedel and M. G. Pelipetz. *J. Opt. Soc. Amer.*, **43**, 1051–2 (*Nov.*, 1953).

Infrared spectra of the anthraxylon constituent of bituminous coal are compared with the spectra of cellulose char and sugar char. The similarity of the spectra indicates the presence of definite molecular configurations in the chars and lends valuable support to the theory that cellulose is an important precursor of coal. A.

535.343–15

261. Similarities in the infrared spectra of homologous compounds. R. G. Fowler and R. M. Smith. *J. Opt. Soc. Amer.*, **43**, 1054–7 (*Nov.*, 1953).

The possibility of treating the environment of molecular structure groups having quasi-stable absorptions as a perturbation on some basic state of the absorbing group is suggested and briefly investigated by the study of homologous series of both esters and acids. It is concluded that the series possess only one group which can be treated in this fashion with certainty, the carbonyl group. Absorptions commonly assigned to C — O — C in the esters, and C — C — O in the acids are probably nonlocalized vibrations of the entire hydrocarbon skeleton, in which the oxygen undergoes large displacements. A.

535.343–15

262. The infrared spectra of propylene and propylene-d_6. R. C. Lord and P. Venkateswarlu. *J. Opt. Soc. Amer.*, **43**, 1079–85 (*Nov.*, 1953).

The infrared spectrum of propylene has been obtained under somewhat higher resolution than that used by previous workers. The improved resolution enables the assignment of many bands on the basis of the band types of the nearly symmetrical top. No important changes are made in existing assignments. The spectrum of propylene-d_6 has been obtained. From an overtone band the unobserved torsional frequency is located at 174 cm^{-1} in propylene and at about 130 cm^{-1} in propylene-d_6. A.

535.343–15

263. Structure of the associated OH valence vibration band in light and heavy acetic, trichloroacetic, and trifluoroacetic acids. N. Fuson and M. L. Josien. *J. Opt. Soc. Amer.*, **43**, 1102–5 (*Nov.*, 1953).

Infrared spectral data in the 3 μ region is given for ordinary and deuterium-substituted acetic, trichloroacetic, and trifluoroacetic acids. Series regularities are pointed out among the many submaxima appearing in the broad associated hydroxyl vibration band. The spacing between the submaxima for the heavy acids appears to be only one-half that for the light acids. A critical discussion is given of various combination band hypotheses which have been proposed to explain the structure of the associated band. An alternative hypothesis is then suggested. This explanation postulates a series of regularly spaced positions of equilibrium of the hydrogen atom between the oxygen atoms in the O—H . . . O chain, these different positions corresponding to different quantized ground state energy levels of the dimer molecule. It is suggested that the different members of a series of absorption submaxima might then be correlated with transitions to the first-excited state from the corresponding different ground states. A.

535.343–15 : 535.375.5 : 539.132

The vibrational spectra and structure of nitrogen tetrasulfide. *See Abstr.* 650

535.343–15 : 539.132

264. Theory of the rotational spectra of allene-type molecules. M. Mizushima. *J. chem. Phys.*, **21**, 1222–4 (*July*, 1953).

The possibility of observing the rotational spectra of allene-type molecules was suggested by the present author and Venkateswarlu [Abstr. 3996 (1953)]. In this paper the effect of nuclear spin on the statistical weight of each rovibrational level and the transition probability between them are calculated. A.

535.343–15 : 539.132

265. Vibration-rotation bands and molecular structure of allene. J. Overend and H. W. Thompson. *J. Opt. Soc. Amer.*, **43**, 1065–70 (*Nov.*, 1953).

Some parallel vibration-rotation bands of allene and allene-d_4 between 3–5·2 μ have been resolved, and values have been obtained for the rotational constants. The values of B_0 for the two isotopic molecules are 0·2974 cm^{-1} and 0·2313 cm^{-1}, and in both cases D_J is not greater than about 10^{-8} cm^{-1}. From these values $r_{CC} = 1{\cdot}30$ Å, which is lower than r_{CC} in ethylene, but close to the value found spectroscopically in ketene. Some earlier results of Eyster for a parallel band of allene have been reconsidered and reasons for the different value of B_0 found by him have been suggested. A.

535.343–15 : 539.132

266. Vibrational spectra of fluorinated aromatics. III. 1, 4-difluorobenzene. E. E. Ferguson, R. L. Hudson, J. R. Nielsen and D. C. Smith. *J. chem. Phys.*, **21**, 1457–63 (*Sept.*, 1953).

For previous papers, see Abstr. 7712 (1951); 5634 (1953). The infrared absorption spectra of gaseous and liquid 1, 4-difluorobenzene were obtained in the regions 2–22 μ and 2–38 μ, respectively, with the aid of LiF, NaCl, KBr, and KRS–5 prisms. The Raman spectrum of the liquid phase was photographed with a three-prism glass spectrograph of linear dispersion 15 Å/mm at 4358 Å. Depolarization ratios were measured for the stronger Raman bands. A complete assignment of fundamental vibration frequencies has been made, and the spectra have been interpreted in detail. The non-planar frequencies have been calculated with the aid of force constants determined for related molecules. A.

535.343–15 : 539.132

267. Vibrational spectra of fluorinated aromatics. IV. 1, 2, 4, 5-tetrafluorobenzene. E. E. Ferguson, R. L. Hudson, J. R. Nielsen and D. C. Smith. *J. chem. Phys.*, **21**, 1464–9 (*Sept.*, 1953).

The infrared absorption spectra of gaseous and liquid 1, 2, 4, 5-tetrafluorobenzene were obtained in the region 2–22 μ with the aid of LiF, NaCl and KBr prisms. The Raman spectrum of the liquid phase was photographed with a three-prism glass spectrograph of linear dispersion 15 Å/mm at 4358 Å. Relative intensities and depolarization ratios have been measured for the stronger Raman bands. A complete

assignment of fundamental vibration frequencies is made and the spectra are interpreted in detail. The values of the nonplanar fundamental frequencies are checked by normal co-ordinate analysis. A.

535.343–15 : 539.132

268. Vibrational spectra of fluorinated aromatics. V. 1, 3-difluorobenzene. E. E. Ferguson, R. L. Collins, J. R. Nielsen and D. C. Smith. *J. chem. Phys.*, **21**, 1470–4 (*Sept.*, 1953).

The infrared absorption spectrum of liquid 1, 3-difluorobenzene was obtained in the region 2–22 μ with the aid of LiF, NaCl and KBr prisms. The contours of the strong infrared bands of the gaseous phase were also observed in the region 5–22 μ. The Raman spectrum of the liquid was photographed with a three-prism glass spectrograph of linear dispersion 15 Å/mm at 4358 Å, and depolarization ratios have been measured for the stronger Raman bands. A complete assignment of fundamental vibration frequencies is given and the spectra are interpreted in detail. A.

535.343–15 : 539.132

269. Vibrational spectra of fluorinated aromatics. VI. Fluorobenzene. D. C. Smith, E. E. Ferguson, R. L. Hudson and J. R. Nielsen. *J. chem. Phys.*, **21**, 1475–9 (*Sept.*, 1953).

The infrared absorption spectra of gaseous and liquid fluorobenzene were obtained in the regions 2–22 μ and 2–38 μ, respectively, with the aid of LiF, NaCl, KBr and KRS–5 prisms. The Raman spectrum of the liquid phase was photographed with a three-prism glass spectrograph of linear dispersion 15 Å/mm at 4358 Å. A complete assignment of fundamental vibration frequencies is given, and the spectra are interpreted in detail. A.

535.343.2

270. Crystal hyperfine structure in the spectra of praseodymium salts. A. M. Hellwege and K. H. Hellwege. *Z. Phys.*, **135**, *No.* 5, 615–19 (1953) *In German.*

The hyperfine structure of PrZn nitrate and PrMg nitrate was investigated at 14°K. It is dependent on the crystal quantum number of the electronic terms, and very dependent on the impurities in the sample, especially small quantities of other rare earths. It is probably due to the interaction of Pr-ions. C. TURNER

535.343.2 : 538.615

271. Zeeman effect of electronic and vibration lines in single crystals of praseodymium and neodymium salts. J. Brochard and K. H. Hellwege. *Z. Phys.*, **135**, *No.* 5, 620–38 (1953) *In German.*

The large spectrograph at Bellevue was used (A. Couder, *Bull. Soc. Franç. Phys.*, 1937, 99S.). The dependence on temperature of several lines of $Pr_2Mg_3(NO_3)_{12}.24H_2O$ was measured. The Zeeman effect was found to be in accordance with earlier measurements and with theoretical expectations. A list is given of wavenumbers as a function of magnetic field strength. A theoretical section gives the quantum numbers for the magnetic field parallel to the crystal axis, the size of the Zeeman splitting, the g-factors of the eigenstates and the Zeeman effect for the field $\perp$ the crystal axis. A description is given of the Zeeman effect of the crystal hyperfine structure. The vibration lines give a pseudo-continuum, no Zeeman effect can be measured. A short description is given of the Zeeman effect of $Nd_2Zn_3(NO_3)_{12}.24H_2O$. C. TURNER

535.343.2–15

272. The infra-red absorption spectrum of potassium chlorate crystals. I. A. K. Ramdas. *Proc. Indian Acad. Sci. A*, **35**, 249–54 (*May*, 1952).

535.343.2–15

273. The infra-red absorption spectrum of potassium chlorate crystals. II. A. K. Ramdas. *Proc. Indian Acad. Sci. A*, **36**, 55–60 (*July*, 1952).

535.343.2–15

274. The infra-red spectrum of magnesium oxide between 1 and 21 microns. A. U. Momin. *Proc. Indian Acad. Sci. A*, **37**, 254–59 (*Feb.*, 1953).

535.343.2–15

275. The infra-red absorption spectra of sodium nitrate and calcite. A. K. Ramdas. *Proc. Indian Acad. Sci. A*, **37**, 441–50 (*March*, 1953).

535.343.2–15

276. The infra-red absorption spectra of sodium chlorate and potassium chlorate crystals. A. K. Ramdas. *Proc. Indian Acad. Sci. A*, **37**, 451–7 (*March*, 1953).

535.343.2–15

277. The infra-red absorption spectrum of silicon carbide. A. K. Ramdas. *Proc. Indian Acad. Sci. A*, **37**, 571–7 (*April*, 1953).

535.343.2–15

278. The determination of infra-red absorption spectra from reflection measurements. T. S. Robinson and W. C. Price. *Proc. Phys. Soc.* [*London*] *B*, **66**, 969–75 (*Nov.*, 1953).

The theory of infrared reflection spectra has been applied (i) to obtain the frequencies and extinction coefficients of the intense absorption bands in polytetrafluorethylene near 8·5 μ, (ii) to determine the number and states of polarization of the fundamental NH stretching absorption bands in a crystal of urea. The reflection method has definite advantages over transmission measurements in both cases. A.

535.343.2–15

279. The infrared spectrum of brucite [$Mg(OH)_2$]. R. T. Mara and G. B. B. M. Sutherland. *J. Opt. Soc. Amer.*, **43**, 1100–2 (*Nov.*, 1953).

Single crystals of brucite were examined under high resolving power between 2 and 3 μ. At least 16 bands were observed, most of which are shown to be OH stretching frequencies and which exhibit a variety of polarization properties. It follows that the unit cell of brucite must be much larger than had been previously assumed and that the positions of the hydrogen atoms have been incorrectly assigned from X-ray data. A.

535.343.2–15 : 535.375.54

280. The vibration spectrum of rutile. B. Dayal. *Proc. Indian Acad. Sci. A*, **32**, 304–12 (*Nov.*, 1950).

This has been studied by group theoretical methods. The structure possesses eleven frequencies, four of which are active in the Raman effect, six in the infra-red and one is inactive in both. The numerical values

of the frequencies have been worked out on the basis of four empirically assumed force constants. It was found that there is a fair agreement between the observed values of the infrared reflection maxima and the calculated values. The observed and calculated values of the compressibility also agree well. A.

535.343.3–15

281. The infrared spectrum of dimethyltriacetylene. A. Weber, S. M. Ferigle and F. F. Cleveland. Letter in *J. chem. Phys.*, **21**, 1613 (*Sept.*, 1953).

The observed positions and intensities of the infrared bands of dimethyltriacetylene in the frequency range 443–3283 cm^{-1} are tabulated. G. I. W. Llewelyn

535.343.3–15

282. A study of the infrared spectrum of the amide group. H. Letaw, Jr and A. H. Gropp. *J. chem. Phys.*, **21**, 1621–7 (*Oct.*, 1953).

The very strong 1560 cm^{-1} band of the N-substituted amide group has been assigned previously either to $\nu(C - N)$ or to $\delta(N - H)$. This investigation consisted of a study of the frequency shifts of this and other bands in the infrared spectra of several N-butyl- and N, N-dibutyl-ethanamides upon substitution of chlorine and fluorine in the 2 position. On the basis of these shifts and other properties of the band in question, observed in the spectra both of the pure compounds and of their CCl_4 solutions, it is concluded that the $\nu(C - N)$ assignment is correct. The apparent absence of the corresponding band from the spectrum of the N, N-disubstituted amide group is explained by the accidental degeneracy of $\nu(C = O)$ and $\nu(C - N)$. Other bands were catalogued and assigned where possible. A.

535.343.3–15

283. Vibrational spectra and calculated thermodynamic properties of 1, 1, 1, 2-tetrachloroethane and pentachloroethane. J. R. Nielsen, C. Y. Liang and L. W. Daasch. *J. Opt. Soc. Amer.*, **43**, 1071–9 (*Nov.*, 1953).

The infrared absorption spectra of CCl_3CH_2Cl in the gaseous and liquid states and of liquid CCl_3CHCl_2 have been obtained in the region from 2 to 38 μ with the aid of LiF, NaCl, KBr and KRS–5 prisms. The Raman spectra of these compounds in the liquid state have been photographed with a three-prism glass spectrograph of linear dispersion 15 Å/mm at 4358 Å. Relative intensities and depolarization ratios have been measured for most of the Raman bands. Complete assignments of fundamental vibrational frequencies have been made, the spectra have been interpreted in detail, and thermodynamic functions have been calculated for the compounds in the gaseous state. A.

535.343.31–14

284. Absorption of 3·3 cm microwaves in chloroform and ethylene dichloride in the liquid state. S. C. Sirkar and D. K. Ghosh. Letter in *J. chem. Phys.*, **21**, 1614–15 (*Sept.*, 1953).

535.343.32–15

285. Origin of the absorption band at 1550 cm^{-1} in proteins. H. Lenormant and E. R. Blout. Letter in *Nature* [*London*] **172**, 770–1 (*Oct.* 24, 1953).

The infrared absorption spectra of proteins dissolved in heavy water has been studied in detail at various values of pH. The curves are reproduced. The band at 1550 cm^{-1} disappears when the heavy water solution (previously adjusted to the isoelectric point) is made alkaline but it is not affected by acidification. This disappearance in alkaline solutions is irreversible and it was also noted that the band disappears when heavy water solutions of plasma albumin, gamma globulin or egg albumin at the isoelectric point are heated at 100°c for 2 minutes. It is concluded that this band is complex, associated in part with two kinds of peptide linkages, one of which is easily deuterated at room temperature and the other only at elevated temperatures or in alkaline solutions. J. Iball

535.343.32–15 : 541.634

New infrared investigations in the *cis-trans* isomerism of *ortho*-halogenphenols. *See Abstr.* 848

535.343.32–15 : 578.088

286. Infrared spectroscopy of biologic materials in apueous solutions. E. R. Blout and H. Lenormant. *J. Opt. Soc. Amer.*, **43**, 1093–5 (*Nov.*, 1953)

A technique is described for obtaining the spectra of biologic materials in aqueous media (H_2O and D_2O) over the frequency range 2000 cm^{-1} to 700 cm^{-1}. It is now possible to use infrared spectroscopy not only for the identification of substances such as proteins and nucleic acids in their native states, but also to study their reactions and interactions with other materials. Examples are shown of the infrared spectra in aqueous solutions of proteins, nucleic acids, and nucleoproteins, as well as suspensions of living bacteria. A.

535.343.4

287. Some considerations on the perturbation of the vibration-rotation spectrum of a polar molecule by compressed gas. L. Galatry, B. Vodar and S. Robin. *C.R. Acad. Sci.* [*Paris*] **237**, 315–17 (*July* 27, 1953) *In French.*

Under high pressure the interactions of molecules of a gas cannot be neglected. In spectra this is shown by the appearance of a central maximum, the intensity of which varies with the nature of the compressed gas. The molecule HCl is considered as a spherical rotator. The compression can be taken into account by changes in the wave function, but this gives a shift in the energy levels which is not observed experimentally. Instead, it is assumed that an extra dipole moment is induced by the surrounding molecules, which is not constant, as the average distances of the other molecules are too large to be considered statistically. The symmetry of the HCl molecule is thus perturbed. The integral for the 1–2 transition can be split up into two parts, which do not vanish simultaneously. The resulting spectrum consists of both parts superposed: rotational states lose their degeneracy. This explanation agrees well with experimental results. A. J. Taylor

535.343.4–14

288. Microwave spectrum of methylamine. I. K. Shimoda and T. Nishikawa. Note in *J. Phys. Soc. Japan*, **8**, 133–4 (*Jan.–Feb.*, 1953).

The accurate positions of 25 lines from 22 200 to 24 600 Mc/s are given. D. H. Whiffen

535.343.4–14

289. Microwave spectrum of methylamine. II. K. SHIMODA AND T. NISHIKAWA. Note in *J. Phys. Soc. Japan*, **8**, 425–6 (*May–June*, 1953).

535.343.4–14

290. An ultra-high-frequency rotational line of HDO. Y. BEERS AND S. WEISBAUM. Letter in *Phys. Rev.*, **91**, 1014 (*Aug.* 15, 1953).

The predicted $3_2 \rightarrow 3_3$ transition has been recorded, together with revised frequency values of 3 Q-branch and 1 P-branch S-band lines. Deuteron quadrupole splitting caused satellite lines 30 kc/s away. J. JACOBS

535.343.4–14

291. Microwave spectrum of DI at 1·5 mm wavelength. J. A. KLEIN AND A. H. NETHERCOT, JR. Letter in *Phys. Rev.*, **91**, 1018 (*Aug.* 15, 1953).

The $J = 0 \rightarrow 1$ transition has been observed in the region of 195 000 Mc/s, the frequencies and assignments of the lines being given. The value obtained for B_0 is 97 532 ± 5 Mc/s and for the quadrupole coupling constant the value −1805 ± 15 Mc/s. The value 2300 Mc/s is obtained for a bond of ionicity 5% derived in accordance with electronegativity data. The difference is attributed to 15–20% s-hybridization of the bond. Some experimental details are given.

H. H. GREENWOOD

535.343.4–14

292. Absorption in the low-frequency wing of the NH_3 inversion spectrum. G. BIRNBAUM AND A. A. MARYOTT. *J. chem. Phys.*, **21**, 1774–7 (*Oct.*, 1953).

The absorption due to the low frequency wings of the NH_3 inversion lines was measured accurately at 2800 Mc/s for a pressure of 10 cm Hg. At this pressure, where the shift in inversion frequency has not set in, the absorption was about 40% larger than that calculated by summing the Van Vleck–Weisskopf expression over the rotational states using known resonance frequencies and line widths. A similar discrepancy was found in comparing the theoretical absorption with previously obtained data at 9000 Mc/s, while at resonance, 24 000 Mc/s theory and experiment were in very good agreement. To investigate various features of pressure broadening, the variation of absorption with pressure (5 to 30 cm Hg), temperature (−12 to 100°c), and frequency (1200 to 2800 Mc/s) was examined. These functional variations are interpretable, for the most part, by the Van Vleck–Weisskopf relation. A.

535.343.4–14 : 539.133

293. Microwave spectrum of HDO. D. W. POSENER AND M. W. P. STRANDBERG. Letter in *J. chem. Phys.*, **21**, 1401–2 (*Aug.*, 1953).

535.343.4–14 : 539.133

294. Microwave spectrum and dipole moment of ethylenimine. R. D. JOHNSON, R. J. MYERS AND W. D. GWINN. Letter in *J. chem. Phys.*, **21**, 1425 (*Aug.*, 1953).

Structural parameters and assignment agree with Abstr. 4015 (1953). Total dipole 1·89 ± 0·01 D, components μ_c 0·89 (approx. perp. to plane of ring) and μ_b 1·67 D. D. H. WHIFFEN

535.343.4–14 : 539.133

295. The microwave spectrum of phosgene. G. W. ROBINSON. *J. chem. Phys.*, **21**, 1741–5 (*Oct.*, 1953).

The microwave spectra of $C^{12}O^{16}Cl^{35}Cl^{35}$ and $C^{12}O^{16}Cl^{35}Cl^{37}$ have been investigated in the region 23 000–28 000 Mc/s. The analyses of the rotational spectra yield for the phosgene molecule: C–O distance = 1·166 ± 0·002 Å; C–Cl distance = 1·746 ± 0·004 Å; and Cl–C–Cl angle = 111·3 ± 0·1°. An analysis of the quadrupole hyperfine structure was made for both isotopic species and the quadrupole coupling constants were obtained for $C^{12}O^{16}Cl^{35}Cl^{35}$. An attempt is made to explain the large observed value of the field dyadic asymmetry parameter η. A.

535.343.4–15

296. Fine structure of the rotation lines of ammonia from $J'' = 14$ to $J'' = 18$. A. HADNI. *C.R. Acad. Sci.* [*Paris*] **237**, 317–19 (*July* 27, 1953) *In French.*

The rotation structure of the NH_3 spectrum was investigated between 250 cm^{-1} and 360 cm^{-1}; five lines were obtained, at 274, 292, 312, 334, and 356 cm^{-1}, corresponding to transitions $\Delta J = +1$ to the levels $J'' = 14$, 15, 16, 17, 18 respectively. The first two lines were clear, the others becoming weaker towards $J'' = 18$. The fine structure of these lines is tabulated and the results compared with theoretical values. There is good agreement, especially for $J'' = 17$. A. J. TAYLOR

535.343.4–15

297. Rotational line-width measurements on NO, HCl, and HBr. D. WEBER AND S. S. PENNER. *J. chem. Phys.*, **21**, 1503–6 (*Sept.*, 1953).

Quantitative measurements of apparent rotational line half-widths are described for NO, HCl, and HBr. Theoretical relations, which apply to vibration-rotation bands with spectral lines of uniform half-width and Lorentz contour, have been used to obtain apparent rotational half-widths from experimental data for CO and for NO. A.

535.343.4–15

298. The fundamental absorption bands in the infrared spectrum of phosphine. V. M. MCCONAGHIE AND H. H. NIELSEN. *J. chem. Phys.*, **21**, 1836–8 (*Oct.*, 1953).

The bands ν_1 and ν_3 yield values of $B^{(xx)}$ and $[(1 - \zeta_3^{(z)})B^{(zz)} - B^{(xx)}]$ as well as values for the centres of the bands. The method of Nielsen for arriving at explicit expressions for the rotation term values of ν_2 and ν_4 has permitted the evaluation also of the quantity $(1 - \zeta_4^{(z)})B^{(zz)}$ and to infer the centres of these bands. The structure of the molecule has been derived from this information and the zeta-sums. The PH distance r_0 obtained is equal to 1·42 Å and the H–P–H angle is equal to 93° 50′. A.

535.343.4–15

299. The fundamental absorption bands in the infrared spectrum of stibine and deuterated stibine. W. H. HAYNIE AND H. H. NIELSEN. *J. chem. Phys.*, **21**, 1839–42 (*Oct.*, 1953).

The four fundamental bands of stibine and the two high-frequency bands in deutero-stibine were

measured. These bands have been sufficiently well analysed to permit the determination of the size and the shape of the molecule. It has been possible, moreover, to correct the band centres for anharmonicity so as to estimate with considerable accuracy the values of the normal frequencies. The constants arrived at for the molecule are as follows: the SbH distance $r_0 = 1{\cdot}71$ Å, the H–Sb–H angle $\alpha = 91° 30'$, the normal frequencies for stibine $\omega_1 = 1988{\cdot}9$, $\omega_2 = 795{\cdot}9$, $\omega_3 = 1974{\cdot}5$, $\omega_4 = 844{\cdot}7$, and for deuterostibine the values $\omega_1^* = 1409{\cdot}4$, $\omega_2^* = 568{\cdot}5$, $\omega_3^* = 1403{\cdot}5$, and $\omega_4^* = 599{\cdot}5$ cm^{-1} are obtained. A.

535.343.4–15

300. Absorption line width in the infrared spectrum of the ammonia molecule. A. Adel. *J. Opt. Soc. Amer.*, **43**, 1053 (*Nov.*, 1953).

The half-width of the 17·103 μ absorption line of the ammonia molecule (NH_3) has been determined by direct observation of line contour with slits of spectral width 0·10 cm^{-1} and with numerical correction for the influence of finite slit width. An upper limit for the NH_3 absorption coefficient half-width at half-height (at a pressure of 30 cm Hg) is 0·10 cm^{-1}. A.

535.343.4–15

301. The rotational spectra of regular and deuterated phosphine and arsine in the region between 50 and 200 K. R. E. Stroup, R. A. Oetjen and E. E. Bell. *J. Opt. Soc. Amer.*, **43**, 1096–9 (*Nov.*, 1953).

Tabular and graphical data show series of lines for phosphine, deuterated phosphine, arsine, and deuterated arsine in the ground vibrational state. Two previously unpredicted series of lines are clearly shown in the spectrum of phosphine and indicated in that of arsine. These additional series are ascribed to rotational transitions occurring while the molecules are in excited vibrational states and their rotational constants as well as the equilibrium rotational constants have been computed. A.

535.343.4–15 : 523.77

The ozone band near 4·7 μ in the solar spectrum. *See Abstr.* 29

535.343.4–31

302. The absorption spectrum of SnS vapour in the ultra-violet and Schumann regions. R. F. Barrow, C. Drummond and H. C. Rowlinson. *Proc. Phys. Soc.* [*London*] *A*, **66**, 885–8 (*Oct.*, 1953).

New spectrograms of the E–X system of SnS have been taken, and additional bands have been assigned to the short wavelength end of this system. A fairly short extrapolation leads to a dissociation limit at about 40 850 cm^{-1} above $v'' = 0$. The energy of dissociation of SnS is found to be 110 kcal mole^{-1}, and this value is shown to be consistent with thermochemical information. The absorption spectrum in the Schumann region has also been examined; two band systems and a region of continuous absorption have been observed. A.

535.343.4–31

303. Absorption coefficient of ozone in the ultraviolet and visible regions. E. C. Y. Inn and Y. Tanaka. *J. Opt. Soc. Amer.*, **43**, 870–3 (*Oct.*, 1953).

As an extension to previous measurements on absorption coefficients of ozone in the vacuum ultraviolet, similar measurements have been made in the near ultraviolet from the overlapping region at 2000 Å up to about 3500 Å and in the visible from about 4000–7500 Å. The absorption coefficient measurements were made using ozone gas obtained by direct vaporization from liquid ozone of high purity (at least 90–95%) and the optical densities measured with a Cary recording spectrophotometer with a 10-cm quartz absorption cell. The method is essentially different from those used by previous investigators, e.g. photoelectric detectors instead of photographic, pure ozone instead of ozonized oxygen, and the absorption cell located at the exit slit instead of between the light source and entrance slit. The absorption coefficients obtained are somewhat consistently lower than those previously reported by Ny and Choong, hitherto considered the most reliable. A.

535.343.4–32

304. Absorption coefficients of water vapour in the vacuum ultraviolet. K. Watanabe and M. Zelikoff. *J. Opt. Soc. Amer.*, **43**, 753–5 (*Sept.*, 1953).

Absorption coefficients of water vapour in the region 1060–1860 Å were obtained by a photoelectric method described in Abstr. 1497 (1953). Pressures (0·08 to 8 mm Hg) of water vapour in the absorption cell were measured with an Alphatron gauge. In the region 1860–1500 Å the absorption coefficients were between the values reported by two groups of investigators. Oscillator strengths of two continua, 1150–1430 Å and 1430–1860 Å, were found to be 0·05 and 0·041, respectively. At Lyman alpha the absorption coefficient was 387 cm^{-1}. Twelve weak diffuse bands forming a progression in the region 1250–1450 and a number of bands in the region 1060–1250 were observed. The absorption coefficients of the continua and bands were independent of pressure, except for some of the bands in the region 1060–1250 Å. A.

535.343.4–32

305. Absorption coefficients of ethylene in the vacuum ultraviolet. M. Zelikoff and K. Watanabe. *J. Opt. Soc. Amer.*, **43**, 756–9 (*Sept.*, 1953).

Absorption coefficients of ethylene have been measured in the region 1065–2000 Å. The most intense absorption has been found to occur in the bands near 1700 Å where the k-values are near 1400 cm^{-1}. Two main continua were found having maxima at 1620 and 1250 Å, with k-values of 750 cm^{-1} and 625 cm^{-1} at the respective maxima. The oscillator strengths are 0·34 for the 1620 Å continuum and 0·30 for the 1250 Å continuum. The ionization region was observed beginning at 1180 Å. A number of new bands were observed and some of them were classified as members of the first Rydberg system observed by Price and Tutte. A discussion of these results in the light of Mulliken's theoretical work is presented. A.

535.343.4–32

306. Absorption coefficients of gases in the vacuum ultraviolet. II. Nitrous oxide. M. Zelikoff, K. Watanabe and E. C. Y. Inn. *J. chem. Phys.*, **21**, 1643–7 (*Oct.*, 1953).

For Pt I, see Abstr. 5963 (1953). Measurements were made in the region 1080–2100 Å. Four continua

were observed with maxima at 1820, 1450, 1285 and 1080 Å having *f*-values of 0·0015, 0·0211, 0·367 and 0·1, respectively. The strongest absorption band in the ultraviolet lies at 1178 Å with an absorption coefficient of 3010 cm^{-1} at its maximum. A number of new bands were observed, and some of them classified. Some of the continua have been interpreted in terms of possible dissociation processes, and a potential energy diagram is presented. A.

535.343.4–32

307. Absorption coefficients of gases in the vacuum ultraviolet. III. CO_2. E. C. Y. Inn, K. Watanabe and M. Zelikoff. *J. chem. Phys.*, **21**, 1648–50 (*Oct.*, 1953).

Measurements were made in the region 1050–1800 Å using a 1-m vacuum monochromator with a phosphor-coated photomultiplier tube as detector. The absorption spectra obtained consisted of three continua (λ_{max} at 1121, 1332, 1475 Å) and possibly a fourth, all being superposed by many bands. For each continuum *f*-values have been calculated. The results have been compared with some theoretical formulations by Mulliken. Upper limits of dissociation energies of the excited states of CO_2 are estimated. A.

535.343.4–32

308. Absorption coefficients of gases in the vacuum ultraviolet. IV. Ozone. Y. Tanaka, E. C. Y. Inn and K. Watanabe. *J. chem. Phys.*, **21**, 1651–3 (*Oct.*, 1953).

Absorption coefficients of ozone gas (purity 90–95%) were obtained in the region 1050–2200 Å by the method described in the preceding abstract. Several strong continua, as well as weak bands, were observed. The curve for absorption intensity shows a minimum (8 cm^{-1}) at about 2015 Å. Below this wavelength, the absorption coefficient increases gradually to a weak maximum (23 cm^{-1}) at about 1725 Å and then rapidly to a strong maximum (420 cm^{-1}) at about 1330 Å. In the region 1050–1450 Å, the absorption intensity does not fall below the value 130 cm^{-1}. The results were compared with Mulliken's treatment of the electronic spectrum of ozone. A.

535.345 : 537.311.31 : 537.312

309. Some electrical and optical properties of synthetic single crystals of zinc sulfide. W. W. Piper. *Phys. Rev.*, **92**, 23–7 (*Oct.* 1, 1953).

The fundamental optical absorption edge and the temperature dependence of electrical conductivity of synthetic single crystals of hexagonal zinc sulphide have been measured, as well as the photoconductivity near the absorption edge. The fundamental absorption coefficient is 1 mm^{-1} at a photon energy of $(3{\cdot}58 \pm 0{\cdot}02)$ eV and increases exponentially by a factor of ten every 0·07 eV up to 10^3 mm^{-1}. The logarithm of the electric resistivity varies linearly as a function of the inverse absolute temperature with a slope of $(3{\cdot}77 \pm 0{\cdot}1)$ eV/2*k*. A peak in the spectral variation of photoconductivity has been observed at the optical absorption edge. A.

535.345–15

310. Optical properties of indium antimonide. M. Tanenbaum and H. B. Briggs. Letter in *Phys. Rev.*, **91**, 1561 (*Sept.* 15, 1953).

Transmission measurements on crystals of InSb show long wavelength limits of absorption of 3·2 μ for impure material ($\rho = 10^{-4}$ ohm cm) and 7 μ for purer samples ($\rho = 7 \times 10^{-3}$ ohm cm). Zone refining of impure samples causes the absorption limit to shift towards the longer wavelength value. Evidence is presented to suggest that the presence of Ni as a 0·1% impurity may partially account for this anomalous behaviour. The long-wavelength limit in pure samples varies with temperature to give a temperature coefficient for the energy gap of -4×10^{-4} eV/°K, agreeing with electrical data if an effective mass of 0·083 is assumed for the charge carriers. D. G. AVERY

535.345.6

311. A filter, of spatial frequencies, for the improvement of the contrast of optical images. A. Maréchal and P. Croce. *C.R. Acad. Sci.* [*Paris*] **237**, 607–9 (*Sept.* 21, 1953) *In French.*

The use of incoherent light in optical image formation is equivalent to a filtering action on the higher spatial frequencies. The perception of small detail can be improved by introducing a correction filter in an appropriate position in the optical system to give a uniform transmission throughout the frequency range. Microphotometer records are shown, illustrating the improvement of contrast obtainable in a simple case. R. W. FISH

535.347–15 : 539.133

The interpretation of infrared dichroism on fibrous protein structures. *See Abstr.* 674

535.349

312. Some illustrations of the theory of the Christiansen optical filters. M. R. Bhat. *Proc. Indian Acad. Sci. A*, **38**, 67–76 (*July*, 1953).

Studies of the spectral character of the light transmitted by Christiansen filters were carried out and are discussed in the light of optical wave theory. A series of spectrograms is reproduced. When the dispersive powers of the solid powder and of the liquid in which it is immersed are nearly equal, the transmission extends over a wide range of the spectrum. Conversely it narrows down with increasing difference in the dispersive powers. The influence of the same factor is also strikingly evident when the wavelength of maximum transmission is shifted towards shorter wavelengths by changing the composition of the liquid. A pronounced asymmetry is also noticeable in the spectral distribution of intensity of the transmitted light. The size of the particles of the powder and the total thickness of the filter are other factors which influence the spectral range of transmission. Of particular interest are the results obtained when the powder is only loosely suspended in the liquid and not tightly packed. A.

535.35 : 551.593.9

Production of sodium airglow excitation by imprisonment of resonance radiation. *See Abstr.* 916

535.371

313. Luminescence of ionic and atomic silver centres in X-rayed phosphors NaCl–Ag. M. L. Kats. *Zh. eksper. teor. Fiz.*, **23**, *No.* 6 (12), 720–7 (1952) *In Russian.*

It is established that in the phosphors NaCl–Ag two types of atomic centres of silver exist, which differ

by their thermal stability and the fluorescent spectrum. It is shown that the brightness of the spectral band 450 mμ, caused by the ionic centres, decreases, and of the 630 mμ, caused by the atomic centres of silver, increases with an increase in the duration of the X-raying of the phosphor. It was found that the form of the luminescent curves and the intensity of coloration, characteristic of the *F*-centres, depend on the concentration of the activator. On the basis of the experimental data obtained, ideas are proposed regarding the nature of the luminescent centres of NaCl–Ag. E. RABKIN

535.371

314. On the fluorescence of organic substances by excitation with fast electrons and γ-rays with particular consideration of specific constitution. L. HERFORTH AND D. ROSAHL. *Ann. Phys.* [*Leipzig*] **12,** *No.* 7–8, 340–7 (1953) *In German.*

535.371

315. On the luminescence of alkaline earth polysulphides. H. GOBRECHT AND D. HAHN. *Z. Phys.*, **135,** *No.* 5, 523–30 (1953) *In German.*

Strontium and barium polysulphides excited by 366 mμ radiation show a yellow to orange-red luminescence. Spectra are measured at various temperatures and the temperature dependence of fluorescence is determined. The phosphorescence shows an exponential form and a small photocurrent is observed ($\sim 10^{-8}$ μA). G. F. J. GARLICK

535.371

316. Phosphorescence of cellulose. A. ROUSSET, R. LOCHET AND J. DARRINE. *C.R. Acad. Sci.* [*Paris*] **237,** 37–8 (*July* 6, 1953) *In French.*

Properly desiccated "cotton wool" shows after long wavelength ultraviolet irradiation, a phosphorescence of duration longer than one second. This is destroyed by exposure to humid air for a few minutes. Cellophane shows a much more feeble effect which suggests the emission is characteristic of the crystalline form of the cellulose in the cotton wool fibres. The emission spectrum is broad with a maximum at 5100 Å. Similar effects are shown by some of the sugars. G. F. J. GARLICK

535.371

317. Fluorescence of acenaphthene crystallized at 20°C. P. PESTEIL. *C.R. Acad. Sci.* [*Paris*] **237,** 235–7 (*July* 20, 1953) *In French.*

535.371

318. Scintillation response of organic phosphors. G. T. WRIGHT. Letter in *Phys. Rev.*, **91,** 1282 (*Sept.* 1, 1953).

Assuming non-radiative losses due to mono- and bi-molecular quenching processes the variation of scintillation efficiency with particle energy is calculated for various particle masses. Results for α-particles and deuterons show close agreement with experiment. G. F. J. GARLICK

535.371

319. Fluorescence, phosphorescence, and photostimulation of NaCl(AgCl) with high-energy irradiation. M. FURST AND H. KALLMANN. *Phys. Rev.*, **91,** 1356–67 (*Sept.* 15, 1953).

Quantitative results are presented on the light-emitting and storage properties of silver chloride activated sodium chloride crystals excited with high-energy radiation. The characteristic of the strong light emission, mostly in the ultraviolet range, upon stimulation by longer wavelength light after pre-excitation with high-energy radiation, is extensively investigated, as well as the fluorescence and phosphorescence. A practically linear stimulated light response as a function of the roentgen dose over a range from about 10^{-2} to 10^{4} roentgens is found. Such a measurement of stimulated light can be performed a considerable time after the exposure to the high-energy radiation and still provide a determination of the dose. Both the ordinary phosphorescence and the stimulated light phosphorescence under suitable conditions may decay very slowly and show many other similarities. The measurements show that the amount of energy stored by the crystal which can later be released as emitted light is greater than 3% of the energy totally absorbed. After a sufficiently long stimulation by visible light the rate of de-excitation becomes very small; further stimulation with light of shorter wavelengths produces a rise in the amount of stimulated light and an increase in the de-excitation rate. The amount of stored energy which can be stimulated as light decays slowly with storage time. This effect is closely correlated with the coloration well known with pure NaCl crystals bleaching a crystal results in a reduced stimulation. Most of the experiments were carried out with a radium γ-ray source, but measurements with X-rays and fast electrons show very similar results. Experiments with fast electrons were performed with doses up to 500 000 rep; saturation then occurs, but after de-excitation (bleaching) the crystal could be re-excited and be used again with no appreciable change in properties. The counting properties of these crystals are rather poor because of small peak heights. A rather complete explanation of these properties can be given by a model assuming a continuous distribution of traps over a small range. The energy released from these traps goes to the activator, from which the energy is emitted as light. A.

535.371

320. Some relative fluorescence efficiencies in the Schumann region. V. W. MASLEN, N. E. WHITE AND S. E. WILLIAMS. *Brit. J. appl. Phys.*, **4,** 303–6 (*Oct.*, 1953).

A vacuum grating monochromator, with photomultiplier detector, and slits about 1·5 Å wide was used to measure the fluorescence quantum efficiency of three (ZnCd)S phosphors, calcium and magnesium tungstates, $ZnSiO_4$: Mn, Apiezon A and B oils and Apiezon L grease, relative to sodium salicylate in the 1000–2000 Å region. The efficiency varies from 10 to 50% of that of sodium salicylate, decreasing toward shorter wavelengths. Evidence for the rapid variation of efficiency in bands of the order of 5 Å wide was found for Apiezon grease in the 1300–1600 Å region. A.

535.371

321. Photo-fluorescence decay times of organic phosphors. J. B. BIRKS AND W. A. LITTLE. *Proc. Phys. Soc.* [*London*] *A*, **66,** 921–8 (*Oct.*, 1953).

A method for measuring to approximately 10^{-9} sec is described. Observations were made of the phase

and modulation of the light from a 7·5 Mc/s air discharge tube, and of the fluorescence excited by this light, using a photomultiplier modulated at 15 Mc/s. The decay times of anthracene, stilbene, terphenyl and diphenylacetylene crystals of various thicknesses were measured. Due to the overlap of the emission and absorption spectra, the technical decay time t_f of a thick crystal is greater than the molecular decay time $(t_f)_0$ observed for a microcrystalline specimen. For anthracene $t_f = 14 \pm 2$ mμsec and $(t_f)_0 = 3{\cdot}5 \pm 1{\cdot}0$ mμsec. This value of t_f agrees with that derived from $(t_f)_0$ and the comparative technical and molecular emission spectra. For each of the compounds studied the molecular decay time $(t_f)_{00}$, in the absence of internal quenching, is of the order of 3–4 mμsec. A.

535.371 : 535.242

A sensitive photometer using modulated light and its application in a uranium fluorimeter. *See Abstr.* 203

535.371 : 537.311.33

322. Luminescence of an electronic semiconductor—zinc oxide. F. I. Vergunas and G. A. Konovalov. *Zh. eksper. teor. Fiz.*, **23**, *No.* 6 (12), 712–19 (1952) *In Russian.*

An hypothesis is proposed that the Zn atoms are responsible only for the dark conductivity of ZnO and that the luminescence centres are the Zn^+ ions. The phosphorescence observed in ZnO at low temperatures can be explained not by thermal emission of localized electrons, but by the necessity of activating the process of the recombination of free electrons with ionized centres. E. RABKIN

535.371 : 537.542

323. A low-cost plastic scintillator. G. E. Pugh. Note in *Rev. sci. Instrum.*, **24**, 878–9 (*Sept.*, 1953).

535.372

324. Fluorescent emission of resonance lines at higher pressures. A. Jabłoński. *Nuovo Cimento*, **10**, 573–80 (*May*, 1953).

The aim of this paper is to show that some phenomena, whose origin has been hitherto ascribed to very loosely bound molecules, can be explained in a natural way on the assumption that their origin is due to the atoms. The phenomena in question were observed by Pringsheim and Jabłoński (1931) in saturated Na-vapour and by Pringsheim and Saltmarsh (1935) in saturated Hg-vapour at pressures beyond the point at which the resonance radiation is contracted as surface resonance at the primary light entrance wall of the container. The most striking of these phenomena are: the reappearance of the luminous beam (beam fluorescence) at higher pressures of the saturated vapour with a spectrum apparently consisting of normal resonance lines, the reappearance of polarization of this fluorescence in spite of the fact that the "normal" resonance radiation is thoroughly depolarized at much lower pressures, the insensitivity of this polarization to the magnetic field, etc. A.

535.375.5

325. Twenty-five years of research on the Raman effect. S. Bhagavantam. *Proc. Indian Acad. Sci. A*, **37**, 350–76 (*March*, 1953).

535.375.5

326. Raman spectrum of oxalyl chloride. B. D. Saksena, R. E. Kagarise and D. H. Rank. Letter in *J. chem. Phys.*, **21**, 1613–14 (*Sept.*, 1953).

The assertion made by Ziomek *et al.* [Abstr. 2340 (1953)] that the polarization method, resolving power, and filtering technique used by Saksena and Kagarise [Abstr. 7715 (1951)] in determining the Raman spectrum of oxalyl chloride were inadequate, is refuted. G. I. W. Llewelyn

535.375.54

327. Intensity ratio of the Raman lines in diamond. R. S. Krishnan and P. S. Narayanan. *Proc. Indian Acad. Sci. A*, **32**, 352–6 (*Nov.*, 1950).

The relative intensities were studied by the spectrophotometric method, using an ultraviolet Spekker photometer in conjunction with a medium quartz spectrograph. [See Abstr. 4683 (1949)]. The values obtained for the fundamental oscillation, 1332 cm^{-1}, were: $I_{Stokes}/I_{anti\text{-}Stokes} = 426$, $I_{Fundamental}/I_{Octave} = 270$, confirming thereby the dependence of the intensity of a Raman line on the fourth power of the emission frequency. A.

535.375.54

328. Raman spectra of crystalline sulphates of zinc, magnesium and sodium. C. Shantakumari. *Proc. Indian Acad. Sci. A*, **37**, 393–400 (*March*, 1953).

535.375.54

329. Raman spectra of crystalline acetates (sodium, magnesium and barium). V. M. Padmanabhan. *Proc. Indian Acad. Sci. A*, **37**, 401–4 (*March*, 1953).

535.375.54

330. Low frequency Raman spectrum of aragonite. G. Olivelli. Letter in *Nuovo Cimento*, **10**, 343–4 (*March*, 1953) *In Italian.*

Lines with a depolarization factor >1 are much weaker in aragonite than in calcite. S. T. Henderson

535.375.54

331. Temperature variation of the Raman spectrum of topaz. R. Srinivasan. *Proc. Indian Acad. Sci. A*, **37**, 405–10 (*March*, 1953).

This was investigated over the range of temperature from 30°c to 450°c, using the λ2536Å radiation of the mercury arc as the exciter. From the observed variation, values of $\chi\left(= -\frac{1}{\tilde{\nu}}\frac{d\tilde{\nu}}{dT}\right)$ have been calculated for the lines 241, 270, 289, 458, 522, 927, 985 and 3643 cm^{-1}. In the case of the first five lines, χ increases with temperature, while for the rest, χ decreases with temperature. Unlike the case of calcite and quartz the absolute values of χ for the different Raman lines of topaz do not show wide variations. The temperature variation of the width of the 458 cm^{-1} line has also been measured. The width of this line is found to increase proportional to the square root of the absolute temperature. A.

535.375.54

332. Raman spectrum of rutile. Polarization studies. P. S. Narayanan. *Proc. Indian Acad. Sci. A*, **37**, 411–14 (*March*, 1953).

535.375.54

333. Raman spectrum of crystalline ammonium hydrogen malate. T. S. Krishnan. *Proc. Indian Acad. Sci. A*, **37**, 415–17 (*March*, 1953).

535.375.54 : 535.43

334. The scattering of light in fused quartz and its Raman spectrum. R. S. KRISHNAN. *Proc. Indian Acad. Sci. A*, **37**, 377–84 (*March*, 1953).

A rectangular specimen of fused quartz of optical A quality was used. The depolarization factors ρ_u, ρ_v and ρ_h were found to be respectively 11·5%, 5% and 80%, and the intensity of scattering was 1/3·5 of that in pure dust-free ether. The Doppler-shifted components in the light scattered by fused quartz was recorded using λ2536 excitation for both transverse scattering and backward scattering. The observed frequency shifts were in general agreement with those calculated from the known elastic constants of fused quartz. The Raman spectrum was recorded with λ2536 excitation. The spectrum exhibits six lines and six bands of varying width and intensity. The frequency shifts are 285, 370, 430, 495, 635, 660, 30 → 120, 775 → 805, 810 → 845, 885 → 940, 1022 → 1098 and 1140 → 1245 cm^{-1}. Besides, there is a weak continuum extending from 30 cm^{-1} to 500 cm^{-1} with well-defined edges. A.

535.375.54 : 548.7

335. The distribution of intensity in the Raman spectrum of diamond. P. S. NARAYANAN. *Proc. Indian Acad. Sci. A*, **34**, 1–13 (*July*, 1951).

This has been derived from microphotometric studies. The spectra exhibit much observable fine structure, including several sharply-defined and intense lines. The intensity curve also exhibits steep drops to zero near the frequency shifts 2176 and 2665 cm^{-1}. These facts are discussed and it is shown that the features mentioned, as also the appearance of second-order Raman spectra generally with crystals, are irreconcilable with the Born–Karman theory of lattice vibrations. A.

535.376 : 778.3

336. Proof of electroluminescence with the help of multilayer colour film. G. WENDEL. *Ann. Phys.* [*Leipzig*] **12**, *No.* 4–6, 222–6 (1953) *In German.*

Contact pictures of electroluminescence of ZnS–ZnO–Cu phosphors are made using Agfa colour film mounted on the phosphor layer between electrodes. Exposures are made for different field strengths. These distinguish between the real electroluminescence effect and the luminescence excited by electrical discharges which become more obvious as the potential is raised. G. F. J. GARLICK

535.39

337. Linear recurrence equations for analyzing multilayers. H. OSTERBERG AND N. E. PAGE. *J. Opt. Soc. Amer.*, **43**, 728–32 (*Sept.*, 1953).

Successive interfacial reflectances or admittances for light incident normally upon a multilayer of N layers obey non-linear recurrence formulae. Linear polynomials in the nth interfacial reflectance of admittance are defined. The partial products Q_ν of these polynomials from $n = \nu$ to $n = N + 1$ are shown to obey linear recurrence formulae relating three successive partial products. Explicit formulae are given for computing the energy reflected or transmitted by the N layers. Methods for calculating the phase retardations produced by reflection from or passage through the N layers are stated. The application of the products Q_ν to the optical admittances is included. A.

535.39

338. Thin metallic films for anti-reflexion coatings on dielectric-air interfaces. F. H. SMITH. Letter in *Nature* [*London*] **172**, 462 (*Sept.* 5, 1953).

Light reflected from a rhodiumized glass-air surface is much weaker than the reflection in reverse. This is probably due to a half-wave phase shift. For glass of $\mu \simeq 1{\cdot}52$ the reflection is zero when the Rh film transmits 70%. Non-metallic matter stands out brightly on such a surface when examined microscopically in normal, bright-field, or vertical illumination. R. A. WEALE

535.39

339. Refinements in the preparation and theory of multilayer films. J. M. STONE. Letter in *J. Opt. Soc. Amer.*, **43**, 927–8 (*Oct.*, 1953).

By careful exclusion of contamination of the zinc sulphide and cryolite layers, improved multilayer reflectors are obtained. Measurements are reported on the transmitted intensity and bandwidth of an interference filter in which each reflector has nine layers (total 19 films). A peak transmission of 0·45 and half-width of 15·4 Å is reported for λ5100. It is inferred that reflectivity is 97·9% and absorption 0·7%. These figures are better than any previously reported. To realize full resolution of such films on a Fabry–Pérot interferometer the surface would need to be flat to $\lambda/250$ and resolving power for 1 cm gap would then be 5 millions. S. TOLANSKY

535.39

340. Experiments concerning infrared diffuse reflectance standards in the range 0·8 to 20·0 microns. J. T. AGNEW AND R. B. MCQUISTAN. *J. Opt. Soc. Amer.*, **43**, 999–1007 (*Nov.*, 1953).

Goniometric measurements of the diffuse reflectance of infrared radiation have been made on 32 samples of 20 different materials. For the most part the materials were finely divided powders of metallic and semi-metallic elements and compounds, with a firmly packed surface presented to the radiation. A globar source operating at 1330°K was used, and the reflectance characteristics of the materials to radiation of wavelengths greater or less than 4·0 μ were studied by means of a quartz filter. Arbitrary comparison factors have been developed by means of which the diffuse reflectance of the materials can be rated with respect to cosine law distribution and spectral reflectivity. The measurements show that of the materials tested, S, Na, Cl, Se and Al have the most favourable characteristics. Several other interesting phenomena of more academic interest which were observed in the experimentation are discussed. A.

535.39 : 537.311.31

341. Conductance and relaxation time of electrons in gold blacks from transmission and reflection measurements in the far infrared. L. HARRIS AND A. L. LOEB. *J. Opt. Soc. Amer.*, **43**, 1114–18 (*Nov.*, 1953).

For sufficiently thin samples and sufficiently large wavelengths a closed expression is derived, relating the electrical conductivity of the gold black directly to the absorption and transmission coefficients. It is found that the electrical conductivity varies with wavelength, and for wavelengths larger than 105 μ this

535.412 : 539.213.26

355. Multiple-beam fringes of equal chromatic order. II. Mechanism of polishing glass. W. F. KOEHLER. *J. Opt. Soc. Amer.*, **43**, 743–7 (*Sept.*, 1953).

The mechanism of polishing glass with barnesite has been studied by obtaining information with multiple-beam fringes of equal chromatic order. This information may be considered support for the Thompson Planing Theory and no evidence is found to support the Beilby Flow Theory. The cutting rate and local smoothness as functions of bowl-feed polishing time are reported for one concentration of barnesite in water. A.

535.412 : 548.0

356. Multiple-beam fringes of equal chromatic order. III. The cleavage of topaz. W. F. KOEHLER AND A. EBERSTEIN. *J. Opt. Soc. Amer.*, **43**, 747–9 (*Sept.*, 1953).

Fringes of equal chromatic order were formed by the film between a silvered cleavage face and a partially silvered optical flat. Crystal cleavage steps were determined from measurements of fringe steps. The *b*-dimension of the unit cell was determined by a method of successive approximations to be $8{\cdot}81 \pm 0{\cdot}07$ Å which agrees with the X-ray value within the experimental error. A.

535.415 : 531.717.7

357. On a method of measuring the radii of curvature of spherical surfaces by comparison. A. BIOT. *Atti Fond. Ronchi*, **8**, 114–17 (*March–April*, 1953) *In French.*

By means of the Newton rings appearing between two spherical surfaces in contact it is possible to find the difference ΔR between the two radii of curvature. With an ordinary microscope, provided with a micrometric eyepiece, the radii of any two rings can be measured, using nearly monochromatic radiation (wavelength λ). If $n' - n$ is the difference between the orders of interference of the two rings considered, then $\Delta R = \dfrac{\lambda(n' - n)R^2}{r'^2 - r^2}$ A.

535.417 : 532.72

358. An interferometer for simultaneous observation of concentration and concentration gradient in liquid columns. W. WEINSTEIN. Letter in *Nature* [*London*], **172**, 461–2 (*Sept.* 5, 1953).

A wavefront is split by a double image prism and passes a double liquid cell, in the two compartments of which are the liquids to be matched. The arrangement is essentially a wavefront shearing interferometer. By suitable arrangement of the beam splitter, fringe displacement can be made either a function of refractive index or of its gradient. S. TOLANSKY

535.417 : 621.374.32

359. A bidirectional electronic counter for use in optical interferometry. F. H. BRANIN, JR. *J. Opt. Soc. Amer.*, **43**, 839–48 (*Oct.*, 1953).

A bidirectional electronic counter has been developed for both additive and subtractive counting of electrical impulses in either binary or decimal notation. Using two coherent syncopated sine-wave input signals, such as may be derived from a Twyman–Green interferometer with a stepped mirror and two phototubes, direction sensing is obtained by pulse forming and selecting circuits which feed pulses to either the "add" or "subtract" channel, depending on the phase relation between the two input signals. In the binary counting circuit, the add and subtract channels each operate separate coincidence amplifiers which select the proper phase for transferring the trigger pulses from one binary stage to the next. In the decimal counting circuit, which consists of a binary stage followed by a reversible ring-of-five, additional coincidence amplifiers determine the direction in which the trigger pulses transfer the count around the ring. Counting rates in excess of 150 kc/s have been achieved with both circuits and higher rates are possible with proper design. Although the bidirectional counting circuit was designed primarily for the purpose of eliminating the tedium of counting interference fringes visually, it can also be used for differential counting with two separate (incoherent) pulse inputs. A review of contemporary developments in this field is given, along with a discussion of applications of the circuit in interferometry and in analogue-to-digital conversion devices. A.

535.42

360. Instrumental diffraction. V. Tests for appreciation of images and the determination of the best focus. G. LANSRAUX. *Rev. Opt.*, **32**, 213–25 (*April*, 1953) *In French.*

For Pt IV, see Abstr. 6672 (1953). Methods of judging image quality are discussed with particular reference to their use in focusing instruments. Judgments based upon geometric optics, Rayleigh criterion, edge gradients, energy distribution, and a new modulation criterion are described. R. W. FISH

535.42

361. Amplitude filters reducing the light of the image of a point diffracted into an annular zone. G. LANSRAUX. *Rev. Opt.*, **32**, 475–99 (*Aug.–Sept.*, 1953) *In French.*

In most optical instruments the almost uniform transparency of the objective gives equal transmission for any luminous ray passing through. The scope of an optical instrument can be enlarged by the use of an amplitude filter, which introduces a systematic local variation in the transmission factor. This paper deals with amplitude filters adapted to a perfect instrument, with a circular diaphragm, correctly focused. A.

535.42 : 535.317.1

362. The effect of source size on the coherence of an illuminating wave. L. R. BAKER. *Proc. Phys. Soc.* [*London*] *B*, **66**, 975–83 (*Nov.*, 1953).

Practical arrangements for determining the coherence of a wavefront are discussed. The intensity distribution in the diffraction pattern of two parallel interferometer slits illuminated by a slit source of variable width is calculated together with the dependence of the fringe visibility on the choice of interferometer slit widths. An experiment demonstrating the effect of source size coherence is described and the results are compared with those to be expected from the above analysis. A.

535.43

363. A system of fringes produced in a transparent film in the neighbourhood of the limiting angle of total reflection. P. BOUSQUET. *C.R. Acad. Sci.* [*Paris*] **237**, 516–18 (*Sept.* 7, 1953) *In French.*

If a thin film of CaF_2 is deposited upon the hypotenuse of a total-reflection prism, fringes are seen at

infinity in the neighbourhood of the total reflection angle. It is suggested that these arise from scattering of light by particles within the film and subsequent multiple reflection. Some difficulties are presented.

R. W. FISH

535.43 : 548.0

364. The influence of optical activity on light scattering in crystals. II. Sodium chlorate. V. CHANDRASEKHARAN. *Proc. Indian Acad. Sci. A*, **32**, 374–8 (*Dec.*, 1950).

As in the case of quartz [see Pt I, Abstr. 5096 (1949)] the selection rules for Raman lines of sodium chlorate have been experimentally verified using $\lambda 2537$ excitation for two different orientations of the crystal. Its 15 Raman lines have been classified as follows into the various symmetry classes possible for a cubic crystal: 70 (E), 83 (F), 103 (F), 123 (F), 131 (A), 179 (E), 482 (E), 487 (F), 627 (A + F), 933 (F), 936 (A), 959 (E), 966 (F), 984(F), 1026 (—). The results agree with earlier ones of Couture and Mathieu [Abstr. 546 (1949)] except for the Raman line 131 cm^{-1} which they classify as belonging to Class E. The Brillouin components are well polarized and weaker than the symmetric Raman line 936 cm^{-1}.

A.

535.43 : 548.0

365. Thermal scattering of light in crystals. II. Diamond. V. CHANDRASEKHARAN. *Proc. Indian Acad. Sci. A*, **32**, 379–85 (*Dec.*, 1950).

For Pt I, see Abstr. 238 (1951). This was studied with a three-metre quartz spectrograph using the $\lambda 2536{\cdot}5$ mercury radiation as exciter. The scattered spectrum shows two pairs of Doppler-shifted components clearly resolved from each other, one pair due to the longitudinal sound waves and the other due to the two sets of transverse sound waves which have nearly the same velocity. The dependence of the frequency shifts on the orientation of the crystal with reference to the incident and observation directions has been verified for five settings. The observed shifts are not in very good agreement with the values calculated from the elastic constants, the transverse components having shifts definitely larger and the longitudinal components having shifts slightly smaller than the expected values. The interesting fact that the shifts of the Brillouin component are generally different for light scattered transversely in opposite directions, the direction of the incident light being kept the same, has been verified in two cases. The difference arises from the fact that the direction of propagation of the elastic waves responsible for light scattering is not necessarily the same in the two cases. The transverse components are found to be 1·5 to 3 times more intense than the longitudinal components, depending on the orientation of the crystal. The principal Raman line 1332 cm^{-1} is 7 to 12 times as intense as the sum of the intensities of the two pairs of Brillouin components.

A.

535.43 : 548.0

366. Thermal scattering of light in crystals. III. Theory for birefringent crystals. V. CHANDRASEKHARAN. *Proc. Indian Acad. Sci. A*, **33**, 183–98 (*March*, 1951).

For the first time, the theory of Doppler shifts in thermal scattering of light in birefringent crystals is worked out and the magnitude of the shift $\Delta\nu$ of the components is given by $\Delta\nu/\nu = \pm v_e/c)\sqrt{(n_i^2 + n_s^2 - 2n_i n_s \cos\theta)}$, where $\Delta\nu$ is the frequency of the incident light, c the velocity of light in vacuum, v_e, the velocity of the elastic wave effective in scattering and n_i and n_s are either of the refractive indices of the crystal for the incident and observation directions. Since n_i and n_s can each take two values, there are four pairs of values (n_i, n_s) and further v_e takes three values. Therefore, there must in general be twelve pairs of Doppler components in the light scattered along a particular direction. The twelve pairs can be divided into four species each with a specific pair of values (n_i, n_s) and consequently specific polarization character. They can be studied individually by the use of proper polarizing devices in the incident and scattered paths. Each species consists of three pairs of components arising from the elastic waves of wavelength $\lambda_e = \lambda/\sqrt{(n_i^2 + n_s^2 - 2n_i n_s \cos\theta)}$, where λ is the wavelength of the incident light in vacuum and propagated along a specific direction. For any particular species, the scattering must be appropriately regarded as "coherent reflection" or "coherent refraction" of light waves by the effective elastic waves according as $\cos\theta < n_i/n_s$ and n_s/n_i or $\cos\theta > n_i/n_s$ or n_s/n_i. There can in general be 3 pairs of Doppler components with finite shifts in the exactly forward scattering. In singly refracting crystals ($n_i = n_s = n$) the expression for shift reduces to the familiar expression $\Delta\nu/\nu = \pm (v_e/c)2n \sin\theta/2$ and in this case there could only be three pairs of Doppler components arising from "specular reflection" of light by elastic waves.

A.

535.434

367. Phase reciprocity relation in light scattering. N. L. RAMANATHAN. *Proc. Indian Acad. Sci. A*, **37**, 385–92 (*March*, 1953).

Describes the experimental verification of a second reciprocity relation in the scattering of light by colloids the existence of which was first pointed out by Perrin (1942). This is in addition to the reciprocity relation established by Krishnan (1935). This second relation has essentially to do with the phase changes which occur in the scattering and has the form $a_{34} = -a_{43}$ for a symmetrical medium having no optical activity, where a_{34} and a_{43} are two of the coefficients in the linear representation relating the Stokes parameters (I, M, C, S) of the incident and scattered beams.

A.

535.435

368. New measurement of the scattering constant of liquid benzene. M. HARRAND. *Ann. Phys.* [*Paris*] **8**, 646–52 (*July–Aug.*, 1953) *In French.*

Measurements with photomultiplier cells give a value for the Rayleigh ratio of $28{\cdot}10^{-6}$ cm^{-1}, at $\lambda = 4358$ Å. This is lower than other photoelectric determinations, but agrees well with photographic measurements, and with the value calculated from the Einstein–Smoluchowski formula as modified by Cabannes and Rocard.

G. F. LOTHIAN

535.435

369. Rayleigh's ratio for benzene and the problem of absolute light scattering determinations. M. HALWER, G. C. NUTTING AND B. A. BRICE. Letter in *J. chem. Phys.*, **21**, 1425–6 (*Aug.*, 1953).

Arguments are given for supposing that the absolute

light scattering measurements of Stamm and Button [Abstr. 7614 (1953)] must be subject to a systematic error. G. F. LOTHIAN

535.435

370. A light scattering study of a mixture of CCl_4 and CS_2. J. POWERS AND R. S. STEIN. Letter in *J. chem. Phys.*, **21**, 1611–12 (*Sept.*, 1953).

Measurements are reported of intensity and depolarization (ρ) as a function of composition; ρ values are compared with computed values. G. F. LOTHIAN

535.514

371. The production of linearly polarized light by reflection on coated metals. H. SCHOPPER. *Optik*, **10**, *No.* 9, 426–38 (1953) *In German.*

It is shown that linearly polarized light can be produced by reflection from a thin non-absorbing layer deposited on an absorbing substrate. The conditions which the optical constants of the substrate, the refractive index and the thickness of the layer must satisfy are derived theoretically and discussed. A large yield of linearly polarized light can be obtained with layers having refractive indices which are easily realized in the u.v. and i.r. The electric vector of the reflected light can be parallel or perpendicular to the plane of incidence according to the metal substrate and non-absorbing layer used. Examples and a comparison with experimental measurements are given. See also Abstr. 3916 (1949); 7921 (1950); 7198 (1952); 4746 (1953). H. G. JERRARD

535.514.2

372. On Pfund's method of measurement of the Brewsterian angle. K. KINOSITA. Letter in *J. Opt. Soc. Amer.*, **43**, 924–5 (*Oct.*, 1953).

The effect of a surface film on the interpretation of Pfund's method for the determination of the Brewster angle is discussed. As most surfaces have films on them, Pfund's method should be regarded as one for determining principal angle of incidence rather than Brewster angle. Measurements are reported for the Pfund angle on clean glass as a function of the relative humidity of the ambient atmosphere. The method is considered applicable to the study of absorption.

S. TOLANSKY

535.515 : 539.133

Dynamic double refraction and the geometrical dimensions of macromolecules in solution. *See Abstr.* 675

535.55 : 539.4.014.3

Fundamental relations in photoplasticity. *See Abstr.* 817

535.551

373. Photo-elastic constants of sodium chlorate. G. N. RAMACHANDRAN AND V. CHANDRASEKHARAN. *Proc. Indian Acad. Sci. A*, **33**, 199–215 (*March*, 1951).

535.551

374. Photo-elastic behaviour of cubic crystals. Displacement of principal axes caused by linear stresses. S. BHAGAVANTAM AND K. V. KRISHNA RAO. *Proc. Indian Acad. Sci. A*, **37**, 589–91 (*May*, 1953).

Measurements are given in respect of the tilts observed of the principal axes in sections of the optical ellipsoid caused by linear stresses applied to prisms cut out of different cubic classes of crystals. In most cases, such effects are characteristic only of the T and T_h classes and are absent in the T_d, O and O_h classes. They serve, therefore, to distinguish between the two types. There is a fair agreement between the measured and calculated values in practically all the cases studied. A.

535.551

375. Photo-elastic behaviour of cubic crystals. New methods of distinguishing between different classes. S. BHAGAVANTAM. *Proc. Indian Acad. Sci. A*, **37**, 585–8 (*May*, 1953).

This is studied in detail for various orientations of chosen prisms belonging to different classes of the cubic system of crystals. It is shown that five out of the eighteen orientations studied furnish a simple experimental test for distinguishing the T and T_h classes from the T_d, O and O_h classes. In the former, on account of the fact that $q_{12} \neq q_{13}$, there is an angular displacement of the principal axis of certain sections of the optical ellipsoid, caused by the application of linear compressional stresses and such an effect may easily be observed and measured. It has also been shown that there is one special orientation for which all the five classes of cubic crystals should exhibit such an effect because $q_{11} - q_{12} \neq q_{44}$. This vanishes for isotropic substances as should be expected. A.

535.551

376. The mechanism of stress birefringence in amorphous solids. J. E. H. BRAYBON. *Proc. Phys. Soc.* [*London*] *B*, **66**, 617–21 (*Aug.*, 1953).

The theoretical treatments of Mueller and Treloar are combined. Mueller's assumption of molecular optical anisotropy due to strain is replaced by Treloar's consideration of alignment, by elastic deformation of the medium, of permanently anisotropic molecular units. An expression is derived for the ratio B_1/B_2 of the absolute stress optical coefficients in terms of $B = B_1 - B_2$, Young's modulus E, Poisson's ratio σ and the refractive index n of the unstressed material. Specimens of CR39 and Marco Resin were tested experimentally and the results of the measurements made of B_1/B_2, B and n at various wavelengths within the range 4000–7000 Å, and of E and σ are given. The theoretical and experimental values of B_1/B_2 are compared. A.

535.551 : 539.389.3

377. An optical method of observing stress relaxation in transparent solids. S. M. CRAWFORD. *Proc. Phys. Soc.* [*London*] *B*, **66**, 954–62 (*Nov.*, 1953).

The relaxation of birefringence produced in two organic glasses after they have been sheared in a modified coaxial cylinder viscometer has been followed at different temperatures by the use of a photocell. For the low rates of loading used it has been found that the relaxation of both the glasses can be represented by a single exponential function, which shows that there is one predominant relaxation mechanism. The relaxation times were measured at different temperatures and cover a range from about 20 sec to $\frac{1}{2}$ m sec. The viscosity has also been measured over the same temperature range and, from the values of the viscosity and relaxation time at a given temperature, the rigidity modulus of elasticity has been determined. Of the two materials used, one, glycerol

sextol phthalate, was more chemically associated than the other, 2′-hydroxy-2 : 4 : 4 : 6 : 5′-pentamethylflavan. This difference was reflected in the temperature variation of the quantities measured. A.

535.56

378. Use of Chaumont's apparatus for dispersion measurements. E. DROUARD. *Rev. Opt.*, **32**, 553–6 (*Oct.*, 1953) *In French.*

The Chaumont elliptic analyser comprises half- and quarter-wave plates which are correct only for one wavelength λ_0. By means of Poincaré's spherical representation corrections for the values given by the apparatus when used with a wavelength $\lambda \neq \lambda_0$ have been calculated. A.

535.561

379. The optical rotatory power of quartz and its variation with temperature. S. CHANDRASEKHAR. *Proc. Indian Acad. Sci. A*, **35**, 103–13 (*March*, 1952).

Numerous formulae have been proposed by several authors to account for the rapid increase in the rotatory power of quartz with decrease of wavelength. These formulae generally consist of a large number of terms both positive and negative, principally of the Drude type, involving various hypothetical characteristic frequencies. An examination of these formulae shows that they do not possess physical justification and are arbitrary in character. In the present investigation it is shown that the data are well represented by the single term formula $\rho = k\lambda^2/(\lambda^2 - \lambda_0^2)^2$ or $av^2/(v_0^2 - v^2)^2$, where $k = 7{\cdot}186$ and $\lambda_0 = 0{\cdot}0926283\ \mu$. Assuming that "$a$" is a constant with temperature and v_0 to vary with it, the thermal variation of the optical rotatory power has been quantitatively accounted for, v_0 being found to vary in the same manner with temperature as estimated from the thermal variation of the refractive indices of quartz. A.

535.561

380. Theoretical interpretation of the optical activity of quartz. S. CHANDRASEKHAR. *Proc. Indian Acad. Sci. A*, **37**, 468–84 (*March*, 1953).

As a result of the interaction between the successive entities constituting the crystal, the spectroscopic behaviour of the individual units would be altered and it is found that this affords a ready explanation of the optical activity of quartz. Replacing each SiO_2 unit by a linear resonator of natural frequency ω_0, it is shown from simple considerations of symmetry, that ω_0 is split into two frequencies ω_1 and ω_2. By a classical discussion, it is demonstrated that this splitting gives rise to optical activity both along and transverse to the optic axis. The expression for the rotatory power is found to be of the form $\rho = \lambda^2/(\lambda^2 - \lambda^2)^2$ which fits remarkably well with the observed data for quartz. From the known values of refraction and rotation, the magnitude of the splitting has been estimated to be 28 Å, which supports the assumption underlying the theory that the resonators are feebly coupled. By assuming that the resonators lie approximately, though not exactly, along the line joining the oxygens in each SiO_2 triplet, it has been possible to quantitatively account for the birefringence and the negative rotation transverse to the optic axis. A.

535.563

381. Some remarks on the optical rotary dispersion of quartz. S. CHANDRASEKHAR. *Proc. Indian Acad. Sci. A*, **36**, 118–22 (*Aug.*, 1952).

The quantum mechanical theory of rotatory dispersion leads to the rule that the sum of the rotational strengths Σa_r of the various terms in a dispersion formula of the Drude type expressed in terms of the characteristic frequencies should be zero. It is shown in this paper that the rotatory dispersion formulae for quartz which had been proposed earlier do not satisfy this summation rule. On the other hand, the single-term formula of the form $\rho = K\lambda^2/(\lambda^2 - \lambda_0^2)^2$ suggested by the author which fits the data along the optic axis accurately from the visible to the ultraviolet region of the spectrum, fulfils the summation condition. It is also shown that the data of Bruhat and Grivet (1935) for the rotatory dispersion of quartz normal to the optic axis is fitted well by a formula of the same form as that given above if we put $K = -3{\cdot}56$ and $\lambda_0 = 0{\cdot}111355\ \mu$. A.

535.563

382. A redetermination of the rotatory dispersion of sodium chlorate. S. CHANDRASEKHAR. *Proc. Indian Acad. Sci. A*, **37**, 458–67 (*March*, 1953).

535.65

383. Considerations on the problem of the perception of colour of objects. L. MARTINELLI. *Atti. Fond. Ronchi*, **8**, 126–33 (*March–April*, 1953).

Some experiments, made by Kompaneysky in Russia, Austria and Argentine during the last fifteen years, are described. The same experiments were repeated in the Institute of Ophthalmology of the Ministry of Public Health of Argentine. The colour selfinduction law of Kompaneysky is reported, with some remarks on its possible practical and theoretical consequences. A.

535.683 : 541.14

384. Multiple reversible color changes initiated by irradiation at low temperature. Y. HIRSHBERG AND E. FISCHER. Letter in *J. chem. Phys.*, **21**, 1619–20 (*Sept.*, 1953).

Colourless solutions of aromatic derivatives of spiropyran, irradiated by ultraviolet, produce a variety of coloured forms. Each substance gives three different colours, at 103°, 123° and 163°K, either by irradiation at the particular temp. or by heating to that temp. after irradiation at 103°K. The forms stable at 123°K are luminescent under 3650 Å radiation. At 273°K all the solutions become colourless. The colours are tabulated. S. T. HENDERSON

535.7 : 612.84

Physiological optics. *See Abstr.* 936–51

535.8

385. A stenopœic aperture by apodization [Le Sténopé apodisé]. P. M. DUFFIEUX. *Rev. Opt.*, **32**, 405–17 (*July*, 1953) *In French.*

A highly absorbing liquid fills the space between the curved face of a plano-convex lens and a parallel glass plate. It forms an apodizing filter whose amplitude and energy are distributed in accordance with the Gauss error function. When used with a convergent lens system, this filter yields a beam in which the energy distribution is always a Gauss

function and whose cross-section may be kept constant over a long distance. Problems of achromatism are discussed. R. W. FISH

535.8

386. Compensation of flexure in instruments with any number of lenses. W. BROUWER. *J. Opt. Soc. Amer.*, **43**, 836–8 (*Oct.*, 1953).

Formulae are derived for the image caused by small decentrations of a multi-lens system. It is shown that for a given decentration there exist nodal and principal points. A new axis can be defined in such a way that the usual projective paraxial laws still hold. Formulae are included for the case where the object is at infinity. A.

535.81

387. Polishing agent for KRS–5 crystals. P. R. YODER, JR AND R. BOERNER. *J. Opt. Soc. Amer.*, **43**, 808 (*Sept.*, 1953).

535.82 : 530.17

388. Microscope imagery as carrier communication. J. E. RHODES, JR. *J. Opt. Soc. Amer.*, **43**, 848–52 (*Oct.*, 1953).

An analogy is drawn in which the optical system in a microscope corresponds to a communication channel; the illumination, to a carrier; and the effect of the object on the illumination, to modulation of the carrier. It is hoped that new techniques in each field can be suggested by their analogs in the other. One such suggestion concerning a new method for obtaining phase contrast microscopy is presented. In the analogy, axial lighting of an object the transparency of which varies from point to point corresponds to a carrier, amplitude modulated and passed before detection through a channel that extends on both sides of the carrier frequency. Dark field illumination of an object corresponds to passing only one side band of a carrier to the detector. Illumination of a transparent object with varying optical thickness corresponds to phase modulation of a carrier. The phase ring in a phase contrast microscope has an analogue in one method of recovering phase modulation, and the optical analogue of another method is presented as another way to obtain phase contrast. A.

535.822.9

389. Coloured phase contrast. M. FRANÇON. *Rev. Opt.*, **32**, 557–61 (*Oct.*, 1953) *In French.*

This is studied specially for reflecting phase plates. It is obtained by a simple quartz plate perpendicular to the axis and placed between the polarizer and the reflecting phase plate. The angle which the incident rectilinear vibration is turned depends on the wavelength. A suitable orientation of the analyser quenches certain wavelengths and gives a coloured phase contrast. A.

535.822.9

390. Design and performance of an infrared microscope attachment. V. J. COATES, A. OFFNER AND E. H. SIEGLER, JR. *J. Opt. Soc. Amer.*, **43**, 984–9 (*Nov.*, 1953).

This employs reflecting optics and is constructed as an attachment to Perkin–Elmer single beam spectrometers. It is mounted after the exit slit of the monochromator in the dispersed beam to minimize possible heating and photochemical effects in the sample. The normal macro functions of the spectrometer are not disrupted by the addition of the microscope. The condenser and objective pair, which are of the Schwarzschild type, operate at N.A. 0·7 with a 0·4 obscuration ratio and are designed to provide optimum imagery in the infrared region of the spectrum. The condenser forms an image of the exit slit at the sample space reduced 8·5×, and the objective provides a 25× enlarged image of the sample at an adjustable diaphragm. A viewing and manipulating system is provided to allow accurate positioning of small samples. The maximum field size is 0·650×0·220 mm. About 35% of the radiation available from the monochromator is conserved by minimizing the number of reflecting surfaces and by utilizing field mirrors to provide efficient energy transfer. The radiation is brought to a separate detector and preamplifier which are connected to the amplifier and recorder of the spectrometer. The minimum sample size which can be effectively studied depends on wavelength and is primarily limited by the available energy. The infrared absorption spectra of fibres, crystals and biological tissue sections, as well as solutions in cells of extremely small volumes have been obtained using this instrument. Performance data is given and a figure of merit determined. A.

535.822.9 : 535.33.07

A 0·8 N.A. reflecting microscope for infrared absorption measurements. *See Abstr.* 235

535.824.8

391. Experimental study of the variation of limit of resolution as a function of coherence. A. ARNULF, O. DUPUY AND F. FLAMANT. *Rev. Opt.*, **32**, 529–52 (*Oct.*, 1953) *In French.*

Results are given of measurements of visual resolution with light which varies in coherence for a two luminous points test. When the pupil diameter is small enough for the image on the retina to be a diffraction pattern, there is good verification of theoretical results of Zernike and Hopkins, showing the effect of the phase factor introduced by Hopkins. When this factor is zero, illumination is always incoherent whatever the width of the source. When this factor is −1 big negative values of coherence are obtained. The consequence is the separation of points whose distance is much smaller than the theoretical limit of resolution. On the contrary, for natural pupil diameter, the variation of size and sign of coherence has a very small effect, practically negligible. Finally there are results obtained with Foucault test, with centred and excentred illumination. A.

HEAT 536

536.2

392. A new analogy in transient heat conduction. R. E. COLLINS. *Amer. J. Phys.*, **21**, 501–3 (*Oct.*, 1953).

An equation of transient heat conduction is derived that involves the velocity of an isotherm and the rate of heat flow across the isotherm. It is shown that this equation is analogous to the equation of wave theory which relates the group velocity and phase

velocity of the wave. It is shown that the equation derived for heat flow serves as a criterion for the propagation of a temperature distribution without change of form in the same way that the analogous equation of wave theory serves a similar purpose. It is also shown that under certain conditions the moving isotherms can be treated as moving heat sources. A.

536.21

393. Measurement of the net thermal conductivity of fibrous substances. Y. TAKAMURA. *J. Phys. Soc. Japan*, **8**, 674–6 (*Sept.–Oct.*, 1953).

When a steady flow of heat is established in a plate, composed of fibres under very intense pressure, a relation between its apparent thermal conductivity (K_c) and the net thermal conductivity of the fibres (K_f) is given approximately as follows

$$\frac{d}{K_c} = \frac{m/\rho}{K_f} + \frac{1}{K_g}\left(d - \frac{m}{\rho}\right),$$

where d is the thickness of the plate, K_g the thermal conductivity of occluded air, m the mass per unit area of the plate and ρ the net density of the fibrous substance. The experimental results for glass wool and cotton were found to be approximately explained by this relation. A.

536.21 : 621.315.322 : 621.365.4.036.2

394. An analytical solution of heat flow versus wire temperature for electric cables buried in plaster. J. E. GOFF. *Applic. and Industr., No.* 7, 160–5 (*July*, 1953).

In radiant heater panels the intrinsic characteristic is a constant I^2R input per foot of cable heating and for long cable life and maximum safety the cable temperature must not exceed a definite limit. Equations derived previously describing the temperature throughout the panel do not relate temperatures to heat input or are not based on conditions normally met in cable heating. Using the equation derived by R. W. Shoemaker [*Radiant heat*: McGraw-Hill, 1948] and Maxwell's results for the electrostatic field of a wire near a grating which show that the closer one approaches to the wire the closer the equipotential lines, and thus the isotherms in the heat system, approach circles, the author derives the expression $(6H/\pi kZ)\,[2\pi AB/(A+B)d - \log_e 2\sin(\pi r/d)] + (At_0 + Bt)/(A+B)$ for the cable temperature t_w, where H/Z is the cable input, k the equivalent thermal conductivity of the media, r the cable radius, d the cable spacing, A the depth of burial of the cable in the panel and B the depth behind the cable of the equivalent panel, t_0 the temperature behind the panel and t room temperature. Hence t_w is a direct function of the heat input per foot of cable and of the equivalent depth of cover of the cable and is approximately inversely proportional to the spacing. Small variations in plaster mix do not affect t_w. Results are given of experimental tests made on cable embedded in sand over gypsum board in a special test house. Agreement between experiment and theory to within 5% was obtained. S. WEINTROUB (R)

536.21 : 621.365.5

395. Thermal basic problem of induction heating. K. SCHÖNBACHER. *Elektrowärme-Tech.*, **4**, 45–50 (*May*, 1953) *In German.*

The temperature distribution in a plane, infinitely thick, hot-plate, for various durations of heating, is derived mathematically and discussed. Constant heat input and constant electric, magnetic and thermal coefficients are assumed. In particular the influence of the penetration depth and of the frequency on the temperature distribution is considered. S. WEINTROUB

536.212.2 : 536.48

396. Thermal conductivity of silver at low temperatures. G. K. WHITE. Letter in *Proc. Phys. Soc.* [*London*] *A*, **66**, 844–5 (*Sept.*, 1953).

Measurements were carried out between 2 and 160°K on a number of specimens of high purity, both before and after annealing. The impurity thermal resistance varies as $1/T$ for a given specimen and is greatly reduced by annealing, while the ideal resistance varies as T^n below 40°K, where n lies between 2 and 3. The resistances show marked departures from the additivity rule. The results are compared with theoretical predictions. [See also Abstr. 6700 (1953).] E. H. SONDHEIMER

536.23

397. The thermal conductivity of nitrogen at pressures up to 2500 atmospheres. A. MICHELS AND A. BOTZEN. *Physica*, **19**, 585–98 (*July*, 1953).

This was measured by the parallel plate method described previously [Abstr. 2402 (1953)] at temperatures 25°, 50° and 75°c and pressures ranging from 1 to 2500 atmos. The results are compared with the prediction of Enskog's theory and with the viscosity data in the same range. A.

536.25

398. Heat transfer from water to ice by thermal convection. J. M. DUMORÉ, H. J. MERK AND J. A. PRINS. Letter in *Nature* [*London*] **172**, 460–1 (*Sept.* 5, 1953).

For bodies determined by one dimension, e.g. a sphere, it is better to use the Nusselt number $Nu = \alpha D/\delta l$ where D is the diameter of the sphere, α the coefficient of heat transfer and λ the thermal conductivity of the surrounding fluid. For a sphere of ice in water the anomalous expansion is taken into account and results were obtained by studying the change in diameter or loss in weight of the sphere. Good agreement was obtained with results calculated from the normal convection law $Nu = 0{\cdot}6(Pr.Gr)^{\frac{1}{4}}$, Pr and Gr being the Prandtl and Grashof numbers. The inversion temperature was shown to be 4·8°c and experiment verified the fact that the direction of motion of the water is opposite on the two sides of this point. E. H. DOCK

536.25

399. The heat loss by free convection from bodies of different shapes in liquids and gases. II. H. SENFTLEBEN. *Z. angew. Phys.*, **5**, *No.* 7, 267–70 (1953) *In German.*

Continuing the subject of previous paper (*ibid.*, **3**, 361, 1951) the heat loss from horizontal and vertical cylinders is considered in more detail. Results are given as ratios of energy loss from a horizontal cylinder to that from a vertical cylinder for the gases ethyl chloride, ethyl ether and liquids carbon tetrachloride, cyclohexane and toluene. Good agreement between calculation and experiment was found. An extension gives the result $Nu = 0{\cdot}533(Gr.Pr)^{\frac{1}{4}}$ for a

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vertical plate (*Nu*, *Gr* and *Pr* are the Nusselt, Grashof and Prandtl numbers respectively). E. H. DOCK

536.37

400. On the problem of the temperature of an object in corpuscular radiation flow. T. A. SANINA, A. A. SANIN AND A. M. TITOV. *Zh. eksper. teor. Fiz.*, **23**, *No.* 6 (12) 703–8 (1952) *In Russian.*

This problem is considered for pulsed corpuscular radiation. The assumption that the flow of electrons liberates heat not only on the surface of the object, but also within the object, is taken as the basis for the calculations. E. RABKIN

536.4.031

401. The supercooling of water. E. K. BIGG. *Proc. Phys. Soc.* [*London*] *B*, **66**, 688–94 (*Aug.*, 1953).

It is shown that suspension of drops at the interface of two insoluble liquids represents a satisfactory method of studying the supercooling of water. The temperatures of supercooling thus found depend on the volume of the sample and the rate of cooling. The inter-relation between temperature, volume and time is derived theoretically from simple probability considerations and is shown to be consistent with experiment. A.

536.421 : 551.1

The melting of iron at high pressures. *See Abstr.* 906

536.422

402. High vacuum evaporation. J. E. TYLER. Letter in *J. Opt. Soc. Amer.*, **43**, 708 (*Aug.*, 1953).

On evaporating a mixture of solids which are miscible and blend on melting, the components of the vapour (or the condensate) are present in a ratio related to that of the original solids by the phase diagram at the given pressure. This principle is used for obtaining the data required for liquid-vapour phase diagrams, which are valuable in the solution of coating problems. G. WITTENBERG

536.423 : 536.7

403. On the reversible adiabatic transformations of a drop of solution in suspension in the atmosphere. L. DUFOUR. *Arch. Meteorol. Geophys. Bioklimatol. A*, **5**, *No.* 3, 346–9 (1953) *In French.*

A drop of a solution is considered, which is without movement relative to the air. It is shown that the evolution of this system in the course of an adiabatic reversible transformation is determined by an independent variable. An equation of this transformation is drawn up which gives the variation of the temperature of the system as a function of the atmospheric pressure. A.

536.423.15

404. Vapour pressure ratio of $^{12}C^{16}O$ and $^{13}C^{16}O$. T. F. JOHNS. Letter in *Proc. Phys. Soc.* [*London*] *B*, **66**, 808–9 (*Sept.*, 1953).

Experiments were made from 61° to 81°K, which included the melting point. The vapour pressure of CO was found to be linearly related to the mole fraction of $C^{13}O^{16}$ present. A few measurements were made below 61·5°K (the transition temperature between the two solid forms). The melting and transition temperatures of the C^{13} material were deduced to be 0·061 and 0·112 deg higher than those of the C^{12} material. L. G. CARPENTER

536.48

405. Temperatures below one degree Kelvin. C. J. GORTER. *Proc. Amer. Acad. Arts Sci.*, **82**, *No.* 3, 159–66 (1953).

Elementary remarks on the notion of temperature, the production of low temperatures and nuclear alignment. R. B. DINGLE

536.48 : 537.312.8

Magnetoresistance of Mg, Cu, Sb, and Al at liquid helium temperatures. *See Abstr.* 475

536.48

406. The rapid separation of He^3 from He^4 by the "heat flush" method. T. SOLLER, W. M. FAIRBANK AND A. D. CROWELL. *Phys. Rev.*, **91**, 1058–60 (*Sept.* 1, 1953).

A practical method is described for separating the He^3 which occurs in well helium from the liquefied mixture using the "heat flush" technique. Approximately 2 l/hr of liquid can be processed, a rate considerably in excess of any previous separations. When the separated isotope is finally withdrawn at room temperature, the concentration of He^3 is approximately 0·5%. This concentration corresponds to an enrichment factor of 3×10^4, which is an order of magnitude greater than enrichment factors reported previously in the literature. A.

536.48

407. Atomic theory of the λ transition in helium. R. P. FEYNMAN. *Phys. Rev.*, **91**, 1291–301 (*Sept.* 15, 1953).

It is shown from first principles that, in spite of the large interatomic forces, liquid He^4 should exhibit a transition analogous to the transition in an ideal Bose–Einstein gas. The exact partition function is written as an integral over trajectories, using the space-time approach to quantum mechanics. It is next argued that the motion of one atom through the others is not opposed by a potential barrier because the others may move out of the way. This just increases the effective inertia of the moving atom. This permits a simpler form to be written for the partition function. A rough analysis of this form shows the existence of a transition, but of the third order. It is possible that a more complete analysis would show that the transition implied by the simplified partition function is actually like the experimental one. A.

536.48

408. Atomic theory of liquid helium near absolute zero. R. P. FEYNMAN. *Phys. Rev.*, **91**, 1301–8 (*Sept.* 15, 1953).

The properties of liquid helium at very low temperatures (below 0·5°K) are discussed from the atomic point of view. It is argued that the lowest states are compressional waves (phonons). Long-range motions which leave density unaltered (stirrings) are impossible for Bose statistics since they simply permute the atoms. Motions on an atomic scale are possible, but require a minimum energy of excitation. Therefore at low temperature the specific heat varies as T^3 and the flow resistance of the fluid is small. The arguments are entirely qualitative—no calculation of the energy of excitation nor of the low-temperature viscosity is

given. In an appendix an expression, previously given, for the partition function is modified to include the effects of phonons. A.

536.48

409. Lambda temperatures of dilute $He^3 - He^4$ solutions. J. C. Morrow. *Phys. Rev.*, **92**, 1–3 (*Oct.* 1, 1953).

In the two-fluid theory of liquid helium, assumptions concerning superfluid He thermodynamic properties can be tested by comparing, in theory and experiment, values both of dT_λ/dx_3 and of T_λ for isotopic mixtures of helium. Comparison of T_λ values is shown to be the more practical plan, since experimental excess chemical potentials in dilute solution are available for use in solving the fundamental differential equations. Error contributed by uncertainty in normal fluid heat capacity is shown to be reasonably unimportant for the dilute cases considered. The differential equations are solved and theoretical values of lambda temperatures are presented so that comparison can be made when experimental lambda points become available. A.

536.48 : 530.162

410. A quantum-statistical theory of liquid helium. K. Buckthought. *Canad. J. Phys.*, **31**, 932–41 (*Sept.*, 1953).

A model for liquid He^4 is set up in which the atoms are regarded as an assembly of Bloch waves following Bose–Einstein statistics. The potential field inside the liquid is estimated. Numerical calculation of the thermodynamic functions shows fair agreement with experiment. The λ-temperature and its variation with pressure are calculated, and are in good agreement with observed values. The model is also applied to liquid He^3. The variation of entropy with temperature is calculated. A.

536.48

411. Thickness of the saturated helium II film. R. Bowers. Letter in *Phys. Rev.*, **91**, 1016 (*Aug.* 15, 1953).

The film thickness d on a foil provided with a wire tail dipping into He was determined gravimetrically. If h is the height in cm of a point on the foil above the He level the results can be represented by $d = 295/h^{1/2}$ atomic layers. In the range investigated (between 1·23°K and 2·15°K) it is independent of temperature. H. London

536.483

412. A new type of helium liquefier. H. M. Long and F. E. Simon. Letter in *Nature* [*London*] **172**, 581 (*Sept.* 26, 1953).

Preliminary description of an "external work" helium liquefier incorporating an elastic bellows hydraulically formed from brass. R. B. Dingle

536.483

413. The regular production of 85 per cent para liquid hydrogen. E. R. Grilly. *Rev. sci. Instrum.*, **24**, 899–900 (*Oct.*, 1953).

The storage of liquid hydrogen has become much less troublesome as a result of regularly producing 85% para liquid instead of "normal." An ordinary liquefaction plant was modified so that the ortho to para conversion is catalysed in the feed gas (at 76°K) and in the liquid within the liquefier. The liquid-phase conversion causes the full liquefaction rate to drop from 25 to 20·5 l/h. Data were also obtained for other liquefaction rates, with and without feed-gas catalysis. A.

536.532 : 536.48

414. The use of thermocouples for measuring temperatures below 70°K. A new type of low temperature thermocouple. T. M. Dauphinee, D. K. C. MacDonald and W. B. Pearson. *J. sci. Instrum.*, **30**, 399–400 (*Nov.*, 1953).

The use of thermocouples such as copper–constantan to measure low temperatures (e.g. ~10°K) may result in considerable uncertainty in the measured temperature. These uncertainties are discussed and a method described for reducing them to ±0·5°. It is shown that thermocouples composed of pure copper against certain dilute copper alloys (e.g. copper + ~ 0·005 wt % tin) have particular advantages for measuring temperatures in the range 2–30°K. A.

536.631

415. The heat capacity of KCl below 4°K. P. H. Keesom and N. Pearlman. *Phys. Rev.*, **91**, 1354–5 (*Sept.* 15, 1953).

The heat capacity of KCl has been found to be proportional to T^3 below 4°K, with a Debye θ of 233°K. This agrees with values calculated from elastic constants and also from the vibration spectrum. A.

536.631

416. The specific heat of graphite from 13° to 300°K. W. DeSorbo and W. W. Tyler. *J. chem. Phys.*, **21**, 1660–3 (*Oct.*, 1953).

The specific heat of high purity Acheson graphite was measured. In the region 13° to 54°K the C_p data follows a T^2 dependence quite accurately in agreement with previous experimental work and recent theoretical investigations of specific heat in strongly anisotropic solids. On the basis of some recent studies for other highly anisotropic solids, it is suggested that the specific heat of graphite will eventually follow a T^3 dependence at still lower temperatures. The derived thermodynamic functions, entropy, enthalpy and free energy, have been determined by graphical integration and tabulated at integral values of temperature up to 300°K. The entropy of graphite at 298·16°K is 1·372 ± 0·005 cal/g-atom deg., of which 0·004 is extrapolated from 13° to 0°K assuming the third law and the T^2 dependence. A.

536.631 : 548.7

417. The lattice vibration specific heat of graphite. J. Krumansl and H. Brooks. *J. chem. Phys.*, **21**, 1663–9 (*Oct.*, 1953).

Recent experiments have shown that the specific heat of graphite varies as T^2 instead of T^3 between 15°K and 80°K. In this paper such a behaviour is shown to be a consequence of the elastic anisotropy of graphite, and therefore an intrinsic property, rather than a particle size effect as suggested by Gurney, or a plate-like behaviour as suggested by Komatsu and Nagamiya. The Gurney treatment is shown to be in error both as to the enumeration of modes and as to the temperature range over which the particle size effect might be of significance. The Komatsu and

Nagamiya treatment is shown to be inconsistent with elasticity theory. The present treatment employs a semirigorous analysis of the normal problem for the transverse vibrations, approximated for long wavelengths. It is found that experimental data from 15–1000°K can be well fitted by dividing the lattice vibrations into two types: (*a*) modes with atom displacements normal to the layer planes with a Debye temperature of 900°K, and (*b*) modes with atom displacements in the planes with a Debye temperature of 2500°K. A.

536.631 : 548.7

418. Computation of mean Debye temperature of cubic crystals from elastic constants. S. L. QUIMBY AND P. M. SUTTON. *Phys. Rev.*, **91**, 1122–7 (*Sept.* 1, 1953).

An improved method is presented for computing the mean Debye characteristic temperature of cubic crystals from the elastic constants. It is based upon an evaluation of the distribution in solid angle of the roots of the cubic equation which describes the propagation of plane acoustic waves in the crystal, and otherwise employs a device due to Hopf and Lechner. The end result is given in simple closed expressions which present no computational difficulty. The uncertainty in the computed value of the mean Debye temperature due to the approximation made in the method is of the order 0·1% when the anisotropy factor of the crystal is as large as 4. A.

536.632

419. Direct measurement of the specific heat at constant volume of pentane and alcohol. M. O. BRYANT AND G. O. JONES. *Proc. Phys. Soc.* [*London*] *B*, 66, 421–3 (*May*, 1953).

Experimental details are summarized, and directly measured C_v and C_p values are given for pentane and ethyl alcohol in the liquid state covering the temperature range from the freezing point to 260°C. The C_v values are compared with those estimated by applying the dilatation correction to the C_p values. Measurements were made at a pressure 1 atm and, for alcohol, at 750 atm; here C_v was found to increase with pressure. E. P. WOHLFARTH

THERMODYNAMICS 536.7/.8

536.7 : 530.162

420. Fluctuations and irreversible processes. L. ONSAGER AND S. MACHLUP. *Phys. Rev.*, **91**, 1505–12 (*Sept.* 15, 1953).

The probability of a given succession of (non-equilibrium) states of a spontaneously fluctuating thermodynamic system is calculated, on the assumption that the macroscopic variables defining a state are Gaussian random variables whose average behaviour is given by the laws governing irreversible processes. This probability can be expressed in terms of the dissipation function; the resulting relation, which is an extension of Boltzmann's principle, shows the statistical significance of the dissipation function. From the form of the relation, the principle of least dissipation of energy becomes evident by inspection. A.

536.7 : 530.162

421. Fluctuations and irreversible process. II. Systems with kinetic energy. S. MACHLUP AND L. ONSAGER. *Phys. Rev.*, **91**, 1512–15 (*Sept.* 15, 1953).

The results of the previous paper are extended to second-order systems, i.e. systems with inertia. Using a generalized definition of the thermodynamic forces, reciprocal relations for the dissipative coefficients in the equations describing irreversible processes are derived. A dissipation function can again be defined, and it can again be used to express the probability functional for fluctuations. A.

536.7 : 530.162

Logical relations among the principles of statistical mechanics and thermodynamics. *See Abstr.* 102

536.7 : 536.423

Reversible adiabatic transformations of a drop of solution in suspension. *See Abstr.* 403

536.7 : 541.135

Thermodynamics of irreversible electrochemical phenomena. *See Abstr.* 836

536.7 : 548.7

422. Thermodynamics of sodium chloride lattice. I. Equation of state. B. DAYAL. *J. sci. Res. Banaras Hindu Univ.*, **1**, 13–20 (1950–51).

The isotherms of rock salt have been drawn at various high temperatures in the range 400 to 1200°K. The part of the pressure due to a static non-vibrating lattice is calculated from the standard expression for potential energy given by Huggins and Mayer. The contribution of the thermal vibration to pressure is obtained from an Einstein energy function and an average Gruneisen constant. The latter quantity has been taken as the statistical average of the Gruneisen constants calculated for the nine discrete frequencies given by the Raman theory of crystal vibrations. The thermal expansion and the compressibility at different temperatures have been calculated from the graphs. The latter is found to agree with the experimental values from 0° to 900°K, but the former is always slightly higher than the observed data. The isothermal at 1010°K is seen to have a minimum on the axis of zero pressure. A.

536.7 : 548.7

423. Thermodynamics of sodium chloride lattice. II. Use of thermal expansion data for drawing isotherms. B. DAYAL. *J. sci. Res. Banaras Hindu Univ.*, **1**, 21–5 (1950–51).

A method of drawing the isotherms of crystals directly from the thermal expansion data has been discussed. The pressure due to the thermal vibrations has been obtained from the values of the Gruneisen constants. The part of the pressure, due to a non-vibrating lattice, has been obtained from the condition that at the volumes measured at the different temperatures the sum of the above two types of pressures is zero. Isotherms of rock salt have been drawn on this basis. The compressibilities calculated from them are in fair agreement with the experimental values. A.

536.76–11 : 541.11

424. A simplified algebraic method for obtaining thermodynamical formulas. H. A. BENT. Letter in *J. chem. Phys.*, **21**, 1408–9 (*Aug.*, 1953).

The method generates Bridgman's tables of first derivatives and extends their scope. [See also Abstr. 678 (1943)]. R. F. BARROW

536.775 : 541.136

The thermodynamics of reversible galvanic cells. *See Abstr.* 839–40

ELECTRICITY 537

THEORY . ELECTRONS 537.1

537.13

425. Thermalization of positrons in metals. R. L. GARWIN. Letter in *Phys. Rev.*, **91**, 1571 (*Sept.* 15, 1953).

It is pointed out that in a metal positrons can transfer energy to the conduction electrons by ordinary Coulomb scattering, and that this leads to a thermalization time of only $\sim 10^{-14}$ sec, contrary to the conclusion reached by DeBenedetti *et al.* (1950). The results of Madansky and Rasetti (1950) and of Bell and Graham (1953) are discussed and are explained in terms of positronium formation. E. H. SONDHEIMER

ELECTROSTATICS . DIELECTRICS 537.2

537.214.08 : 621.317.723

426. The theory of mechanical electrometers. R. J. MUNICK. *Amer. J. Phys.*, **21**, 512–17 (*Oct.*, 1953).

The theory of a generalized mechanical electrometer is developed in terms of the direct capacitances and potential differences between each pair of conductors comprising the electrometer, regardless of which is the movable conductor. A criterion is established for stable static equilibrium of the movable conductor. A distinction is made between voltage and charge measurements. General expressions are obtained for voltage and charge sensitivities, period and the magnitude of random fluctuations in position of the movable conductor. A.

537.224

427. On the capacitance of a spherical condenser. F. BERTOLINI. Letter in *Nuovo Cimento*, **9**, 852–4 (*Sept.*, 1952) *In Italian.*

In practice a spherical condenser has an opening to allow the condenser to be charged. The error in the classical formula, due to this opening is calculated. J. J. MIRANDA

537.226

428. Method of obtaining streaming orientation and simultaneous determination of dielectric properties in macromolecular solutions. B. JACOBSON. *Rev. sci. Instrum.*, **24**, 949–54 (*Oct.*, 1953).

A method has been devised for the measurement of the dielectric constant and the specific conductance of aqueous solutions undergoing streaming with velocity gradients between 0 and 10 000 sec^{-1}. The solution to be investigated is placed in the annular space between two concentric cylinders forming the measuring cell. Electrodes are inserted in the walls of the cylinders of which the outer is fixed and the inner is rotated. Two types of cells are used; the electrical field in one case being perpendicular to and in the other case parallel with the stream lines. The impedance of the cell with the solution investigated is determined with a specially constructed Schering bridge making measurements possible in the frequency range 0·05 to 5 Mc/s and at specific conductances of 1 to 200 μmho/cm. The advantage of the bridge circuit employed is that the conductance of the cell is balanced by a variable air condenser, making possible and accuracy of 0·1% in the values for both conductance and dielectric constant. Excellent mechanical and electrical stability and a low interference level are necessary for high accuracy. Experiments with solutions of sodium thymonucleate show that the current interpretation of the dielectric properties of macromolecules must be revised. The term streaming dielectric investigations is suggested as a suitable name for studies with the type of instrument described. A.

537.226

429. Dielectric polarization of a dipolar lattice. J. A. POPLE. *Phil. Mag.*, **44**, 1276–81 (*Nov.*, 1953).

This paper is concerned with a rigorous treatment of the dielectric polarization of a model consisting of unpolarizable point dipoles fixed on the sites of a lattice but free to rotate. The dielectric constant of this system is expanded in inverse powers of the temperature as far as T^{-3}. It is shown that for small dipole moments the Debye and Onsager approximate formulae both overestimate the polarization, the Onsager result being the more accurate of the two. Previous treatments of this problem did not make adequate allowance for the long-range effects of boundary field polarization. A.

537.226.2

430. The measurement of dielectric constant of gaseous helium. M. S. KHAIKIN AND L. A. PROZOROVA. Letter in *Zh. eksper. teor. Fiz.*, **23**, *No.* 6 (12) 733–4 (1952) *In Russian.*

The measurement was carried out at a frequency of 9500 Mc/s at the temperature of liquid helium, 2–4°K. The measurements consisted in determining the shift in the natural frequency of a hollow resonator upon filling it with gaseous helium. It was found that $\varepsilon = 1{\cdot}0000690 \pm 0{\cdot}0000003$. The accuracy of measuring was approx. 0·4%. E. RABKIN

537.226.2

431. Studies in electrets. I. C. BHATNAGAR AND D. R. BHAWALKAR. *Proc. Indian Acad. Sci. A*, **36**, 170–4 (*Sept.*, 1952).

The steady current characteristics of carnauba wax were studied with the view to understanding the mechanism of formation and properties of electrets. Careful investigations showed that the "hysteresis effect" was totally absent in steady currents observed while cooling and heating carnauba wax under the

influence of an electric field. The electric field was varied from a few volts per cm to 10 kV/cm. The rate of change of current with temperature is very small below 75°C for all voltages and increases very rapidly for higher temperatures up to the melting points. Beyond the melting point the rate again falls. A.

537.226.2

432. The theory of the dielectric constant of ionic crystals. I. J. YAMASHITA. *Progr. theor. Phys.*, **8**, 280–90 (*Sept.*, 1952).

The dielectric constants of χ_0 and χ of the alkali halide crystal are calculated on the basis of the quantum theory of solids. The variational method of Slater and Kirkwood is used in the energy-calculations and Landshoff's method is adopted for evaluating the exchange integrals among the non-orthogonal wave functions. The relation between the various theories, due to Shockley, Mott and Fröhlich, of the dielectric constant of ionic crystal has been clarified. The numerical results for LiF are in good accordance with the experiment. A.

537.226.2

433. Microwave observation of the collision frequency of holes in germanium. T. S. BENEDICT. Letter in *Phys. Rev.*, **91**, 1565 (*Sept.* 15, 1953).

Microwave measurements of dielectric constant as function of temperature were made on *p*-type Ge. Assuming a free-carrier model and an energy-dependent relaxation time τ, an effective mass for holes $m^{\times} = (0{\cdot}30 \pm 0{\cdot}13)m_0$ was obtained, whence $\tau = 3{\cdot}6\times10^{-7}T^{-2,3}$ sec. (Previously, an energy-independent τ was assumed for electrons in *n*-type Ge [Abstr. 4077 (1953).] J. FRANKS

537.226.2

434. Complex dielectric constants of some aliphatic alcohols at 9733 Mc/sec. N. KOIZUMI. Letter in *J. chem. Phys.*, **21**, 1898–9 (*Oct.*, 1953).

Measurements of ε' and ε'' for 9 simple alcohols at 9733 Mc/s from 5 to 50°C. D. H. WHIFFEN

537.226.2

435. Restricted rotation in polar gases near the critical point. F. E. HARRIS AND B. J. ALDER. Letter in *Nature* [*London*] **172**, 774 (*Oct.* 24, 1953).

An alternative interpretation of the dielectric loss results for CH_3F above the critical point reported by David, Hamman and Pearse [Abstr. 6483, 7263 (1952)], in terms of Onsager's and Kirkwood's theories gives $g = 1$ and no restriction of rotation in the gas. D. H. WHIFFEN

537.226.2 : 621.3.011.5

436. The dielectric constant of a liquid containing spherical particles. S. H. M. EL-SABEH and J. B. HASTED. Letter in *Proc. Phys. Soc.* [*London*] *B*, **66**, 611–12 (*July*, 1953).

Measurements carried out on suspensions of spherical particles of polystyrene 0·2–0·4 μ in diameter in soap solution show that the dielectric constant decreases linearly from 74·2 to 64·7 as the concentration of polystyrene increases from 0 to 10%. The value obtained for pure water was 78·2. The methods used were those described by Collie *et al.*, [Abstr. 963 (1948)] at $\lambda = 9{\cdot}2$ cm and Buchanan [Abstr. 2700 (1952)] at $\lambda = 1{\cdot}26$ and $3{\cdot}29$ cm. A value of $1{\cdot}50 \pm 0{\cdot}03$ was found for the Fricke parameter β, which has a calculated value of 1·5 for spherical particles. G. HOWELLS

537.226.2 : 621.3.011.5 : 621.315.612.4

437. Some dielectric properties of barium-strontium titanate ceramics at 3000 megacycles. L. DAVIS, JR AND L. G. RUBIN. *J. appl. Phys.*, **24**, 1194–7 (*Sept.*, 1953).

The dielectric constant $\varepsilon'/\varepsilon_0$ and loss tangent $\tan\delta$ of barium strontium titanate ceramics were measured as a function of temperature and static electric field at frequencies of 10 kc/s, 500 kc/s and 3000 Mc/s. No frequency dependence of $\varepsilon'/\varepsilon_0$ was apparent at temperatures above the Curie point. An increase in $\tan\delta$ was observed in going from the low frequencies to 3000 Mc/s, but above the Curie point the values were not excessively large. A description of the 3000 Mc/s bridge construction and operation is given. A.

537.226.3 : 621.3.017.143 : 621.315.616.96

438. The dielectric losses of various filled phenolic resins. R. L. LOFTNESS. *Dissert. E.T.H. Zürich, No.* 1842, 63 *pp.* (1952) *In German.*

A summary of the nature of dielectric loss, including ionic conduction, interfacial and orientation polarizations, is followed by a discussion of Debye's and Wagner's theories of dielectric loss. Some 60 graphs show the variation of dielectric losses in filled phenol-formaldehyde resins, as functions of the temperature, frequency, type, quantity and grain size of the filler, type and extent of curing the resin and the moisture content. The moisture absorbing and ionizing characteristics of the filler markedly affect the dielectric loss. There are 92 references. J. H. MASON

ELECTRIC CONDUCTION . CURRENTS 537.3

537.311.31

439. Origin of the electrical resistance of thin films of platinum subjected to a relatively high d.c. voltage. M. ERNY. *C.R. Acad. Sci.* [*Paris*] **237**, 387–9 (*Aug.* 5, 1953) *In French.*

The resistances of 6-month-old films produced by Mostovetch and Feldman were measured, a large p.d. of 300–500 V was applied, the specimens were allowed to cool to room temperature and the resistances were again measured. Successive experiments were carried out. The initial resistance increase is due to increased dislocations due to thermal shock, whereas the slower subsequent decrease is due to an annealing process. C. A. HOGARTH

537.311.31 : 537.312 : 535.345

Some electrical and optical properties of synthetic single crystals of zinc sulfide. *See Abstr.* 309

537.311.32

440. The electrical resistance of graphite at low temperatures. J. M. REYNOLDS, H. W. HEMSTREET AND T. E. LEINHARDT. *Phys. Rev.*, **91**, 1152–5 (*Sept.* 1, 1953).

The resistance of natural graphite and of high

purity polycrystalline graphite was measured over a range of temperature from room temperature down to 1·35°K. The resistance of large-crystal natural graphite as found to increase with increasing temperature over the entire range. For polycrystalline graphite the resistance was found to increase smoothly as the temperature was lowered to about 20°K. At this temperature the resistance begins to level off until around 5°K it is virtually independent of temperature, at a value about double the room temperature resistance. Below 5°K the resistance seems to fall slightly. A.

537.311.32 : 539.26

441. Silicocarbon—thermal decomposition product of silicone resin. M. HATOYAMA, W. SASAKI AND Z. ISHII. Letter in *J. Phys. Soc. Japan*, **8**, 134–5 (*Jan.–Feb.*, 1953).

Samples of silicone resin DC–801 were heated in vacuum for 1 hr at temperatures of 500–1100°C, giving products with room-temperature resistivities of $10^{12} - 1$ Ω.cm. The resistance/temperature behaviour of the 1050°C sample is similar to that of black SiC, and the X-ray diffraction pattern suggests the presence of both SiC and graphite. F. F. ROBERTS

537.311.33

442. On the forming of germanium surfaces. R. THEDIECK. *Z. angew. Phys.*, **5**, *No.* 5, 163–5 (1953) *In German.*

Careful experiments suggest that (*a*) the action during forming extends out to the edge of the crater formed, (*b*) formed contacts with the same peak back voltage can be obtained for points of various shapes, weight and material, (*c*) the formed surface is *p*-type, (*d*) the effect is simply a thermal $n \rightarrow p$ conversion during the forming, so that the rectification characteristic ultimately is more representative of a *p-n* junction than of a metal/Ge contact. C. A. HOGARTH

537.311.33

443. The preparation and properties of semiconducting arsenides. F. GANS, J. LAGRENAUDIE AND P. SEGUIN. *C.R. Acad. Sci.* [*Paris*] **237**, 310–13 (*July* 27, 1953) *In French.*

A method is described for the preparation of gallium and indium arsenides by heating mixtures of the elements in a specially designed vacuum furnace. Macrocrystalline aggregates of about 1 gm mass were obtained. Thermoelectric power measurements were made on *n*-type samples of both compounds, whilst rectification effects were found corresponding to both *n*-type and *p*-type GaAs, the *n*-type sample showing marked effects. Photoconductivity was also observed in GaAs, with a threshold wavelength of 1·1 μ, showing similarity with Si. Conductivity-temperature measurements confirmed a value of about 1·1 eV for the width of the energy gap in GaAs. D. G. AVERY

537.311.33

444. Note on shot effect in semi-conductors and flicker effect in cathodes. A. VAN DER ZIEL. *Physica*, **19**, 742–4 (*Aug.*, 1953).

A seeming discrepancy in the theory of shot effect in semiconductors is clarified. It is shown that the problems of flicker effect caused by emission centres and of shot noise in semiconductors can be treated in a similar way. A.

537.311.33

445. The electrical conductivity and current noise of carbon resistors. I. M. TEMPLETON AND D. K. C. MACDONALD. *Proc. Phys. Soc.* [*London*] *B*, **66**, 680–7 (*Aug.*, 1953).

The variation of resistance with temperature, pressure and magnetic field in several types of carbon resistor has been measured down to helium temperatures. Temperature variation is interpreted on the basis of an assembly of contacts with two different ranges of barrier height. A resistance decrease with pressure of approximately 0·1% per atmosphere is found in carbon compound resistors, and a small size effect variation with magnetic field in the case of carbon film resistors. Noise measurements have been made which show that the $1/f$ law holds at all temperatures. The temperature dependence of the noise is not in agreement with Macfarlane's theory [Abstr. 314 (1951)] in terms of a single activation energy. Measured noise power is found to be closely proportional to I^2, while the ambient temperature noise level at 10^{-5} A for small resistors is expressible as $\overline{\delta R^2}/R^2 \simeq 10^{-11}\, \delta f/f$. A.

537.311.33

446. A more exact treatment of the equations describing dielectric relaxation and carrier motion in semiconductors. J. KEILSON. *J. appl. Phys.*, **24**, 1198–200 (*Sept.*, 1953).

Previous treatments of the linearized equations describing hole and electron flow in a homogeneous semiconductor have not been wholly satisfying mathematically. An exact treatment of these equations is undertaken and it is demonstrated that the departure from complete local charge neutrality implicit in the equations corresponds to a polarization attributable to local variations of conductivity. The dielectric relaxation is described and exact expressions for the effective mobility and diffusion coefficients are obtained. The corrections to the older values are of magnitude τ_r/τ, where τ_r is the relaxation time and τ the lifetime. For semiconductors, these corrections are negligible. A.

537.311.33

447. Electrical properties of gold–germanium alloys. W. C. DUNLAP, JR. Letter in *Phys. Rev.*, **91**, 1282 (*Sept.* 1, 1953).

Au acts as an acceptor impurity with two levels 0·15 eV above the filled band and 0·20 eV (trapping) below the conduction band. Segregation coefficient of Au in Ge is $1{\cdot}5 \times 10^{-5}$ and the solubility is about 10^{15} atoms cm^{-3}. C. A. HOGARTH

537.311.33

448. A possible mechanism for *l/f* noise generation in semiconductor filaments. L. BESS. Letter in *Phys. Rev.*, **91**, 1569 (*Sept.* 15, 1953).

The variation of noise output power with frequency is obtained on the assumption that low frequency noise is caused by the random fluctuation of the number of mobile charges due to random creation and annihilation of trapping centres, which are confined to the surface. J. FRANKS

537.311.33

449. Electrical conductivity of mechanically disturbed germanium surfaces. E. N. Clarke and R. L. Hopkins. Letter in *Phys. Rev.*, **91**, 1566 (*Sept.* 15, 1953).

The variation of resistivity with temperature of a sandblasted Ge surface was measured. It is concluded that a large concentration of extrinsic carriers exists in the surface layer, and that two acceptor levels are introduced. The resistivity of the disturbed surface increases on annealing. J. FRANKS.

537.311.33

450. Anisotropic resistivities of selenium crystals at high frequencies. H. W. Henkels and J. Maczuk. Letter in *Phys. Rev.*, **91**, 1562 (*Sept.* 15, 1953).

Careful measurements at 200 Mc/s show a lower value of resistivity than with d.c. and no hysteresis effect on temperature cycling. Pronounced anisotropy is observed for measurements $\parallel$ or $\perp$ $C-$ axis.

C. A. HOGARTH

537.311.33

451. On the electrical conductivity of cuprous sulfide: A diffusion theory. I. Yokota. *J. Phys. Soc. Japan*, **8**, 595–602 (*Sept.–Oct.*, 1953).

Mixed electrical conduction of solid cuprous sulphide at the β-phase, a p-type semiconductor, is treated theoretically, though phenomenologically, for the case where the current is maintained at a constant intensity, insufficient to electrolyse out copper ions. The drift motion of acceptors (vacant copper ion lattice points) may be described with a diffusion equation, which can be linearized when some physical assumptions are made, and then can easily be integrated under proper initial and boundary conditions. Theoretical expressions for the potential distributions are derived for the process of tending to the limiting stationary state as well as for the stationary state. An expression for the residual potential—a potential which remains after the current has been switched off and decays according as the initial homogeneity is recovered—is derived. V–I characteristics for the stationary current are also given. Calculated results are compared with experiments by Miyatani and Suzuki, exhibiting satisfactory agreements. A.

537.311.33

452. Cuprous oxide rectifier characteristics. J. Lees. *Proc. Phys. Soc.* [*London*] *B*, **66**, 622–32 (*Aug.*, 1953).

Using a substitution bridge method, the current voltage and reverse capacitance voltage characteristics of a cuprous oxide rectifier have been obtained at 0°c, 30°c and 70°c. The capacitance characteristic is found to be temperature independent in the above range. The assumption of a Schottky barrier (or an allied class of barriers) is not in agreement with the experimental results. Using the capacitance characteristic and a single adjusted value of the dielectric constant of cuprous oxide, it is found possible, with only one temperature dependent parameter, to predict theoretical reverse current voltage relations in good agreement with experiment. A.

537.311.33 : 535.34–15

453. Optical studies of injected carriers. I. Infrared absorption in germanium. R. Newman. *Phys. Rev.*, **91**, 1311–12 (*Sept.* 15, 1953).

This was observed by a modulation technique. For injection into low-resistivity material, the data indicate a linear relationship between injected carrier density and injection current. For injection into high-resistivity material, departure from a linear relationship is indicated. The absorption spectrum of injected carriers resembles that of extrinsic carriers. A.

537.311.33 : 535.34–15

454. Optical studies of injected carriers. II. Recombination radiation in germanium. R. Newman. *Phys. Rev.*, **91**, 1313–14 (*Sept.* 15, 1953).

The radiation produced by the direct recombination of electrons and holes in germanium is studied. The observed spectral distribution is in fair agreement with theory. For injection into high resistivity, as well as into doped material, the radiation is observed to be a linear function of injection current. Possible explanations for this are discussed. Magnetic concentration of carriers produced changes in the radiation intensity. Polarization of the radiation at oblique angles of emergence is observed. A.

537.311.33 : 535.34–15

455. Absorption of infrared light by free carriers in germanium. H. B. Briggs and R. C. Fletcher. *Phys. Rev.*, **91**, 1342–6 (*Sept.* 15, 1953).

The absorption of infrared light associated with the presence of free carriers in germanium was measured by injecting these carriers across a p–n junction at room temperature. The absorption is found to be proportional to the concentration of carriers. The absorption as a function of wavelength shows the same rather sharp maxima previously observed in normal p-type germanium. These bands are found to change with temperature. An explanation of this absorption is offered in terms of a degenerate energy band scheme. A.

537.311.33 : 535.34–15

456. Infrared absorption in *P*-type germanium. W. Kaiser, R. J. Collins and H. Y. Fan. *Phys. Rev.*, **91**, 1380–1 (*Sept.* 15, 1953).

This was investigated at various temperatures down to 5°K. The absorption coefficient is proportional to the hole concentration and shows band structure, a strong band beyond 10 μ and two weaker bands at shorter wavelengths. The strong band is shown to be caused by excitations within the filled band because of the presence of holes. The relative strengths of the two weaker bands change with temperature, only one being observable at low temperatures. A.

537.311.33 : 537.312 : 541.133

457. Theory of a.c. space-charge polarization effects in photoconductors, semiconductors, and electrolytes. J. R. Macdonald. *Phys. Rev.*, **92**, 4–17 (*Oct.* 1, 1953).

A linear theory is developed of the a.c. behaviour of solid or liquid materials containing charge carriers which can move freely within the material but cannot

leave it through the electrodes. The theory applies for any degree of dissociation of neutral centres and recombination of positive and negative charge carriers, but these carriers are assumed to have been produced by dissociation from only one species of neutral centre. The mobile carriers may be electrons, positive holes, positive ions, negative ions, positive ion vacancies, or negative ion vacancies. The general solution for the admittance of the material is obtained for an arbitrary ratio between the mobilities of positive and negative carriers, but, because of the complexity of the result, it is only discussed in detail in the present paper for the following special cases: (*a*) charge carriers of only one sign mobile, arbitrary recombination time; (*b*) charge carriers of both signs mobile with the same mobility, arbitrary recombination time; and (*c*) charge carriers of both signs mobile with unequal mobilities and very short recombination time. In case (*a*), two dispersion regions may appear, with that at lower frequencies arising from recombination and the other from the finite mobility of the carriers. Both regions follow Debye dispersion curves accurately over a wide frequency range, making it possible to represent the electrical behaviour of the material for any recombination time by means of a simple equivalent circuit containing only frequency-independent elements. In cases (*b*) and (*c*), only the motional dispersion region appears, and it again follows Debye curves. Finally, the results of the present theory are compared with those of other theories of a.c. space-charge effects in semiconductors and electrolytes. A.

537.311.33 : 537.312.5

458. Electron multiplication in silicon and germanium. K. G. McKAY AND K. B. McAFEE. *Phys. Rev.*, **91**, 1079–84 (*Sept.* 1, 1953).

This was studied in the high fields of wide *p–n* junctions for voltages in the prebreakdown region. Multiplication factors as high as eighteen were observed at room temperature. Carriers injected by light, α-particles, or thermal-generation are multiplied in the same manner. The time required for the multiplication process is less than 2×10^{-8} sec. Approximately equal multiplication factors are obtained for injected electrons and injected holes. The multiplication increases rapidly as "breakdown voltage" is approached. The data are well represented by ionization rates computed by conventional avalanche theory. In very narrow junctions, no observable multiplication occurs before Zener emission sets in [see Abstr. 7897 (1951)]. It is incidentally determined that the efficiency of ionization by α-particles bombarding silicon is $3{\cdot}6 \pm 0{\cdot}3$ eV per electron-hole pair produced. A.

537.311.33 : 537.32

459. Some experimental studies of the conductivity and thermo-electromotive force of Cs_3Sb photocathodes. T. SAKATA. Note in *J. Phys. Soc. Japan*, **8**, 125–6 (*Jan.–Feb.*, 1953).

Thermoelectric power and conductivity were measured for several specially prepared cells in the temperature range 268–343°K. Results indicate a high impurity concentration ($> 10^{20}$ cm^{-3}) with a depth of about 0·5 eV at room temperature.

C. A. HOGARTH

537.311.33 : 537.32

460. Some experimental studies of the conductivity and thermo-electromotive force of Cs_3Sb photocathodes. II. T. SAKATA. Note in *J. Phys. Soc. Japan*, **8**, 272–3 (*March–April*, 1953).

See preceding abstract. The measurements were extended to 221°K. *P*-type conduction was observed over this range. The temperature variation of thermo-electric power indicated an impurity activation energy of about 0·4 eV in agreement with conduction measurements on the same cell. The acceptor levels are probably due to an excess of Sb.

C. A. HOGARTH

537.311.33 : 538.632

461. Experimental and theoretical investigations of the isothermal and adiabatic Hall effects in selenium. R. DIESTEL. *Z. Naturforsch.*, **8a**, 453–7 (*Aug.*, 1953) *In German.*

Supposing an arbitrary dependence of the mean free path on energy, the isothermal and the adiabatic Hall coefficients are calculated for a *p*-type semiconductor by means of the theory of electrons. The difference between the Hall coefficients calculated in this way decrease considerably with increasing thermal conductivity of the lattice. Even for substances with very small thermal conductivity (i.e. Se, etc.), the difference amounts to only about 1% in relation to the isothermal Hall coefficient. This theoretical result is proved by measurements on Se; the measured difference slightly exceeds the limit of error $(5{\cdot}2 \pm 4{\cdot}1)\%$. A.

537.311.33 : 538.632

462. Current carrier lifetimes deduced from Hall coefficient and resistivity measurements. L. P. HUNTER, E. J. HUIBREGTSE AND R. L. ANDERSON. *Phys. Rev.*, **91**, 1315–20 (*Sept.* 15, 1953).

The conventional expression for the Hall coefficient in semiconductors is based on the assumption of an infinite rate of carrier recombination. If the latter assumption is not made, diffusion currents are present which change the value of the Hall coefficient. It is this change in the Hall coefficient which forms a basis for an independent measurement of carrier lifetime. Methods for obtaining the value of a parameter, m, which contains the bulk lifetime, τ, and the surface recombination velocity, s, are described. Lifetimes, as deduced from Hall measurements, compare reasonably well to lifetimes obtained on the same samples by injection methods. A.

537.311.33 : 541.113

The atomic heat of germanium below 4°K. *See Abstr.* 827

537.311.33 : 669.783 : 621.317.73

463. Four-probe instrument for resistivity measurements of germanium and silicon. A. L. MACDONALD, J. SOLED AND C. A. STEARNS. Letter in *Rev. sci. Instrum.*, **24**, 884–5 (*Sept.*, 1953).

Details of construction are given for the instrument which is used for exploring the resistivity of ingots.

C. A. HOGARTH

537.311.33

464. The temperature dependence of the zero bias resistance of cuprous oxide rectifiers. A. OKAZAKI, H. TUBOTA AND H. SUZUKI. Note in *J. Phys. Soc. Japan*, **8**, 431–2 (*May–June*, 1953).

The results over the range 0 to 100°C are inter-

preted in terms of a theory given by Landsberg [Abstr. 6512 (1952)] and a derived variation of hole mobility with temperature is given. This variation is similar to that for the variation of the Hall mobility for holes measured by Angello. C. A. HOGARTH

537.311.4

465. Resistance of an imperfect contact between two metals. Comparison with experimental results on thin granular films. N. NIFONTOFF AND M. PERROT. *C.R. Acad. Sci.* [*Paris*] **237,** 228–31 (*July* 20, 1953) *In French.*

See Abstr. 8419 (1953). The theory is extended to cover different distances between the metals and an integrated effect for ten or more grains in series is calculated. C. A. HOGARTH

537.312.5

466. On the evaluation of measurements of rise and decay of photoconductivity. G. HÖHLER. *Ann. Phys.* [*Leipzig*] **12,** *No.* 7–8, 379–85 (1953) *In German.*

537.312.5

467. "Phosphorescent" effect in lead selenide. P. A. LEE. Letter in *Canad. J. Phys.*, **31,** 1023–4 (*Sept.*, 1953).

At 90°K photoconducting layers of PbSe are found to exhibit a slow decay of photocurrent after illumination due to trapped electrons. The effect appears to be independent of impurities present.

G. F. J. GARLICK

537.312.5

468. On the relation between the speed of response and the detectivity of lead sulfide photoconductive cells. R. C. JONES. *J. Opt. Soc. Amer.*, **43,** 1008–13 (*Nov.*, 1953).

As a starting point attention is called to an empirical relation between the detectivity and the time constant of PbS photoconductive cells. This relation, found by E. D. McAlister, states that the ratio $\mathfrak{D}/\tau$ of the detectivity $\mathfrak{D}$ in the reference condition C to the time constant τ is approximately constant $\mathfrak{D}/\tau = 6{\cdot}7\times10^{10}$ (watt. sec)$^{-1}$. This relation holds for tests with radiation from a 500°K blackbody, and holds for both cooled and uncooled cells. The relation is based on data concerning the detectivity and time constant of about eighty different cells of domestic and foreign manufacture with time constants in the range from 3 μsec to 3 msec. It is shown that this relation has a number of important consequences. For cells that accord with McAlister's relation, one draws the following conclusions: (1) PbS cells are Class II detectors. (2) The value of the figure of merit, M_2, may be determined. (3) It is disadvantageous to match the time constant of the cell to the duration of the signal pulse; rather, one should always use a cell with a time constant large compared with the signal duration. (4) Cooling the cell is of no advantage for signal frequencies greater than the crossover frequency; cooling the cell is merely one method of increasing the time constant of the cell. (5) PbS cells are remarkably versatile detectors. McAlister's relation is purely empirical, and has no known theoretical basis. It is therefore possible that the relation, and the consequences just described, may be modified in the future. In the meantime, the relation provides a working basis of considerable practical importance. A.

537.312.5 : 535.215.4

469. On the development of the caesium-on-oxidized-silver photocathode during heat treatment. V. SCHWETZOFF. *C.R. Acad. Sci.* [*Paris*] **237,** 320–2 (*July* 27, 1953) *In French.*

Describes measurements of photoelectric (u.v. and visible irradiation) and thermionic emission made during the development of an $AgO.Cs_2$ cathode. By prolonged heating the thermionic emission could be reduced practically to zero but a stable photoelectric (u.v.) emission was still obtainable.

C. G. MORGAN

537.312.5 : 535.343–31

470. Correlation between photoconductance and ultraviolet spectrum of anthracene crystals. D. J. CARSWELL. Letter in *J. chem. Phys.*, **21,** 1890 (*Oct.*, 1953).

537.312.5 : 535.37

471. Studies on the photovoltaic effect. III. I. LEVIN, J. R. WIEBUSH, M. B. BUSH AND C. E. WHITE. *J. chem. Phys.*, **21,** 1654–9 (*Oct.*, 1953).

For Pt II, see Abstr. 295 (1952). Further studies in the ultraviolet region between 4000 and 2500 Å indicate that the magnitude of the photopotential derived from a photoactive substance in solution is dependent on the absorption of the solution. Aliphatic and aromatic alcohols, hydroxy acids and phenols produce practically no photopotentials between 3000 and 8000 Å. The photovoltaic behaviour of 38 organic halides has been studied. Methyl iodide produced the highest photopotential of any of the compounds used. The normal halides other than the iodides were inactive. In general the iso, secondary, and tertiary halides were more active than the corresponding normal halides. Results on 89 compounds other than halides are listed. A.

537.312.5 : 537.311.33

472. Photoelectromagnetic and photodiffusion effects in germanium. T. S. MOSS, L. PINCHERLE AND A. M. WOODWARD. *Proc. Phys. Soc.* [*London*] *B*, 66, 743–52 (*Sept.*, 1953).

A voltage arises across an illuminated slab of germanium in the direction of illumination due to the difference in mobility between electrons and holes (photodiffusion effect). If the slab is placed in a magnetic field perpendicular to the direction of illumination, a voltage is produced at right angles to both field and illumination (photoelectromagnetic effect); voltages as great as 0·5 V have been obtained. The latter effect saturates for large illumination and its limiting value provides a convenient measure of the surface recombination velocity. A.

537.312.62

473. Two-fluid models of superconductivity with application to isotope effects. P. M. MARCUS AND E. MAXWELL. *Phys. Rev.*, **91,** 1035–42 (*Sept.* 1, 1953).

A general form of the two-fluid model of a superconductor, which includes all previous forms, is set up and the underlying assumptions examined in the light of the lattice vibration theory of superconductivity. Thermodynamic relations are derived and their consistency with the observed isotope effects indicated.

Specialization to the α model of Casimir and Gorter (1934) permits fitting recent precise critical field data and evaluation of the parameter α characterizing different superconductors. Comparison is made with Koppe's [Abstr. 1558 (1948)] form of the two-fluid model, which is shown not to fit all the data, and simplified and limiting forms of his equations are given. A.

537.312.62

474. Superconductivity at very high pressures. P. F. Chester and G. O. Jones. *Phil. Mag.*, **44**, 1281–90 (*Nov.*, 1953).

A method is described for the realization of very high pressures at liquid helium temperatures. First results are given of its application to studies of superconductivity under pressures up to 44 000 atm. Bismuth is shown to become superconducting under pressure. T_c for tin is shown to vary approximately linearly with volume up to 17 500 atm. The value of dT_c/dp for thallium is found to be negative, in disagreement with previous work. A.

537.312.62 : 534.22

Velocity of sound in superconducting lead and tin. *See Abstr.* 166

537.312.62 : 539.11

The surface free energy of a metal-superconducting state. *See Abstr.* 637

537.312.8 : 536.48

475. Magnetoresistance of Mg, Cu, Sb, and Al at liquid helium temperatures. G. B. Yntema. *Phys. Rev.*, **91**, 1388–94 (*Sept.* 15, 1953).

The resistance of pure samples was measured at temperatures between 1·1°K and 4·22°K in transverse magnetic fields ranging from zero to 22 kG. In a magnesium specimen the dependence of the magnetoresistance on the resistance in zero field was in strict agreement with the Kohler rule, even though the temperature coefficient of the resistance in zero field was negative. The copper samples also showed negative temperature coefficient of resistance, and the temperature dependence of the magnetoresistance was qualitatively in accord with the Kohler rule. The second derivative with respect to temperature of the resistance of the copper samples in zero field was negative in the liquid helium range. A.

537.312.8 : 537.311.62

476. Galvano-magnetic effects at high frequencies. B. Donovan and E. H. Sondheimer. Letter in *Proc. Phys. Soc.* [*London*] *A*, **66**, 849–51 (*Sept.*, 1953).

The effect of a magnetic field on the surface impedance of a metal is calculated on the basis of the free-electron model. There is a non-zero magnetoresistance effect at low frequencies which drops to zero in the infrared. The Hall effect at high frequencies is also considered. E. H. Sondheimer

537.313 : 513.83 : 621.372 : 621.3.011

477. The second fundamental theorem of electrical networks. C. Saltzer. *Quart. appl. Math.*, **11**, 119–23 (*April*, 1953).

An extension of the work of 2 previous papers [Abstr. 1611 (1945), 302 (1952)]. A network may be replaced by its Thévenin or Norton representation. The fundamental theorem for nodal networks is proved, and it is shown that the nodal equations have a unique solution. The relation of the theorems for the two representations is studied. J. L. Synge, *ibid.*, 214 (*July*, 1953) acknowledges "flaw in reasoning," and offers an alternative proof. L. S. Goddard (R)

537.321

478. Thermoelectric effects due to stationary and moving asymmetrical temperature gradients in mercury. N. Fuschillo. *Proc. Phys. Soc.* [*London*] *B*, 66, 649–53 (*Aug.*, 1953).

Stationary and moving asymmetrical and symmetrical temperature distributions are applied to mercury, employing maximum temperatures from the melting point to the boiling point of mercury and an asymmetrical temperature gradient ratio of 1 : 96. No electromotive force greater than 0·005 μV was detected until maximum temperatures greater than 176°c were reached. These e.m.f's were found to be spurious and were traced unambiguously to the finite electrical conductivity of Pyrex glass above this temperature. The experiments confirm the conclusions drawn from earlier work on copper and platinum [Abstr. 1649 (1953)], and show that the Thomson e.m.f. produced by a temperature difference is independent of the shape of the temperature gradient and the rate at which it is changing. A.

537.39 : 535.14

The quantum radiation of a given current. *See Abstr.* 200

ELECTRIC DISCHARGES 537.52

537.521 : 537.533

479. The field emission initiated vacuum arc. I. Experiments on arc initiation. W. P. Dyke, J. K. Trolan, E. E. Martin and J. P. Barbour. *Phys. Rev.*, **91**, 1043–54 (*Sept.* 1, 1953).

It is known that electrical breakdown between metal electrodes can be initiated by field emission. The present work concerns a further study of that initiation process under conditions of excellent vacuum and a clean cathode surface. As the field current density from the single crystal tungsten emitter is continuously increased, the normal emission is terminated by an explosive vacuum arc. Since this breakdown occurs in less than a microsecond, the experimental observations were obtained by use of pulse electronic techniques. The magnitude of the electric field, current density and work function at the cathode were simultaneously determined prior to breakdown. From this investigation it has been established that: (1) the vacuum arc was initiated at a critical value of the field current density of the order of 10^8 A/cm^2; (2) breakdown was predictable and not random; in fact easily recognizable conditions preceding arc formation have been established; at current densities just below the critical value, an electron emission process was observed, which apparently involved both high electric fields and high temperatures; (3) arc formation did not require cathode bombardment by material from the anode or from residual gases; (4) breakdown was independent of the applied microsecond voltage in the range $5 < V < 60$ kV, provided the critical current density

was not exceeded; (5) the current during arc exceeded the initiating field current by a factor of at least 100. A.

537.521 : 537.533

480. The field emission initiated vacuum arc. II. The resistively heated emitter. W. W. Dolan, W. P. Dyke and J. K. Trolan. *Phys. Rev.*, **91**, 1054–7 (*Sept.* 1, 1953).

Electrical breakdown between clean metal electrodes in high vacuum was observed when the field current density at the single crystal tungsten cathode exceeded a critical value of the order of 10^8 A/cm^2. At current densities just below the critical value, an electron emission process was observed which apparently involved both high temperature and high electric field. Calculations are presented for the emitter temperature increase due to the resistive mechanism for both the steady state and the transient solution. Emitter geometries used for the calculations approximated those obtained from electron micrographs of several emitters. The calculations show that the resistive heating was sufficient to melt the emitter at the critical current density, assuming the accepted value of the physical constants for the polycrystalline metal. A.

537.523

481. Influence of irradiation on discharge current in an ozonizer. S. Deb, A. K. Saha and M. Ghosh. *J. chem. Phys.*, **21**, 1486–92 (*Sept.*, 1953).

The "electronic surface charge theory" of the effect developed by Deb and Ghosh, on a suggestion of Mitra, is explained and is further extended by taking into account the role played by the negative ions formed in the discharge space. It is assumed that the effect of irradiation is to decrease the charges deposited on the surface and to increase those in the volume. The former reduces the discharge current due to the neutralization of the surface charges and the latter increases the main discharge current due to the applied voltage. The net effect is generally a decrease if conditions are favourable for the capture of the electrons in the volume by neutral gas molecules, leading to the formation of negative ions. In all other conditions the effect is generally an increase. It is shown that the theory, in its extended form, is able to account for the origin and the characteristics of both the positive and the negative effects. Numerical calculations of the various rate processes involved in the proposed mechanism are also made. It is shown that the relative magnitudes of these processes are such as to support strongly the "electronic surface charge theory" of the effect. A.

537.523.4

482. Fundamental processes of the initiation of electrical discharges. C. G. Morgan and D. Harcombe. *Proc. Phys. Soc.* [*London*] *B*, **66**, 665–79 (*Aug.*, 1953).

The role of electrode and gas processes in the production of electrons which initiate spark discharges is investigated. The results for metal surfaces covered with thick ($\gtrsim 10^{-5}$ cm) oxide layers are consistent with the view that electrons may be liberated from sites of negative ions on the oxide. For metals covered with thin ($\sim 10^{-7}$ cm) tarnish films the emission is field dependent, but in these cases involves the action of a surface charge of positive ions in setting up an intense field across the film causing tunnel effect emission: in both cases the macroscopic applied electric field was of the order of 10^5 V. cm^{-1}. The influence of surface micro-geometry on the cold cathode emission processes is examined. These experiments in dry air, hydrogen and argon ($p \sim$ 760 mm Hg) indicated that initial electron production by detachment processes and the quenching of metastable atoms does not play a significant part in the discharge initiation. The influence of moisture on these processes is examined. Recent work on breakdown of liquid dielectrics is discussed in the light of the present work. A.

537.523.5

483. The recombination factor of electrons. E. M. Tseĭrov. *Elektrichestvo*, **1953**, *No.* 4, 42–4. *In Russian.*

The theoretical investigation of arcing processes is complicated by, among other things, the absence of quantitative data on the recombination factor of electrons. No theoretical methods have so far been suggested for calculating this factor. The author suggests a method based on comparatively simple statistical considerations. The simplicity of the method is demonstrated by proving from physical facts that only linear approximations are required. The principle of the computation is derived from methods usual and successful in calculations of ionization processes. B. F. KRAUS

537.523.5 : 523.75

484. The 3000 Mc ion plasma noise radiated from arc discharge and solar eruption. T. Takakura, K. Baba, K. Nunogaki and H. Mitani. Note in *J. Phys. Soc. Japan*, **8**, 426–7 (*May–June*, 1953).

D.C. discharge in air was found to radiate intense radio noise at 3000 Mc/s polarized along the discharge current which is considered to be due to ion plasma oscillation near the cathode. The intensity corresponded to thermal emission of 10^6–10^7°K for the current range 0·5–5 A and was little affected by imposing a magnetic field along the discharge current. Effects of different electrodes, air pressure, and shape of electrodes are considered. Such radio noise may explain the outbursts of solar radio emission which can escape through the over-dense plasma of the outer layer of the sun only during eruptions.

G. M. BROWN

537.523.5 : 621.3.018 : 621.3.014.31

485. Low-frequency self-generated oscillations in the d.c. carbon arc. B. H. List and T. B. Jones. *Elect. Engng*, **72**, 612–16 (*July*, 1953).

Experiments are described the results of which show that uniform symmetrical oscillations of current, voltage, light and sound occur in the arc at current values just below the hissing stage. These oscillations, which occur only after the anode has attained its characteristic shape, are shown to be due to the rotation of the anode spot. The rotation is caused by the unsymmetrical magnetic field of the arc current itself at the anode surface. An empirical equation expressing the frequency of the oscillations as a function of current and electrode parameters is given.

J. DUTTON

537.525

486. On the theory of probes in electro-negative gases. J. WILHELM. *Ann. Phys.* [*Leipzig*] **12**, *No.* 7–8, 401–9 (1953) *In German.*

Extends the theory of the plane probe to include the presence of negative ions. The range of validity of the space charge formula obtained and its application to the determination of plasma characteristics are discussed. J. DUTTON

537.525.3 : 537.525.72/.8

487. Reversal to negative Joshi effect by intense irradiation. H. J. ARNIKAR. Letter in *J. Opt. Soc. Amer.*, **43**, 804 (*Sept.*, 1953).

See Abstr. 4122 (1953). Describes further expts. on the influence of external irradiation on the properties of corona discharges. J. D. CRAGGS

537.525.4

488. Electrical discharges at low gas pressures between metallic surfaces. R. ARNAL. *C.R. Acad. Sci.* [*Paris*] **237**, 308–10 (*July* 27, 1953) *In French.*

Describes pre-spark discharges that are observed at low pressures (not specified) between metal plates, and that take the form of cumulative processes giving quasi-oscillatory discharges. It is suggested that these are triggered off by field emission of electrons, followed by secondary emission processes.

J. D. CRAGGS

537.525.4 : 535.338

489. Relative time dependence of the emission of line and background from the vacuum spark. J. C. WAHR, W. W. MCCORMICK AND R. A. SAWYER. Letter in *J. Opt. Soc. Amer.*, **43**, 804–5 (*Sept.*, 1953).

Describes expts. with photomultiplier tubes on the spectral emission, especially with Al electrodes, from condensed vacuum discharges, with peak currents varying up to 63 kA. The relation between line emission and background for high and low currents is briefly shown. J. D. CRAGGS

537.525.8

490. An example of plasmoidal phenomena in a d.c. glow discharge in oxygen. N. SKOGEN. *K. Norske Vidensk. Selsk. Forhandl.*, **26**, *No.* 5, 16–18 (1953).

Describes certain visible forms of glows in oxygen at pressures varying from about 0·02 to 0·03 mm Hg.

J. D. CRAGGS

537.525.8

491. The delayed cathode glow produced in a neon discharge tube at low pressure. D. J. ECKL. Note in *Canad. J. Phys.*, **31**, 1015–16 (*Sept.*, 1953).

Describes an increase in the light emission in the afterglows following square excitation pulses in neon (pressures ~1 mm Hg) which is attributed to radiative recombination. J. D. CRAGGS

537.525.8

492. Origin of striations in discharges. G. D. MORGAN. Letter in *Nature* [*London*] **172**, 542 (*Sept.* 19, 1953).

A general critical discussion of striations in glow discharges. It is concluded that, on the evidence available, the striations are a property of the plasma and do not involve a cathode mechanism. Further, it is suggested that the striations may be due to a standing wave system associated with plasma oscillations. J. D. CRAGGS

537.525.8

493. The direct current associated with microwave gas discharge between coaxial cylinders. III. K. MITANI. *J. Phys. Soc. Japan*, **8**, 642–5 (*Sept.–Oct.*, 1953).

For Pt II, see Abstr. 1662 (1953). The author has found that the microwave power in the region of glow discharge does not change the electron states but only controls the discharge area. In this point, the microwave discharge and the normal d.c. discharge are very alike. A.

537.525.8 : 621.3.015.532 : 621.3.013

494. The influence of a transverse magnetic field on an unconfined glow discharge. W. D. MCBEE and W. G. DOW. *Commun. and Electronics*, *No.* 7, 229–38 (*July*, 1953).

Describes experiments with a 3 kW glow discharge in air at pressures from 0·3 to 10 mm Hg in the presence of magnetic fields from 0 to 7000 gauss. Detailed results at about 1·2 mm Hg pressure and with glow current ~0·6 A show the effect of increasing magnetic field on the visible form of the discharge, the cathode sputtering rate, average discharge potential differences and distributions, the variation of discharge potentials with time and the transverse wind generated by the plasma. The experimental results are explained in terms of an approximate theory of the mobilities of ions and electrons in the presence of a magnetic field.

J. DUTTON

537.527.3

495. On the discharge between positive point and plane in compressed air. M. TOITOT AND A. BOULLOUD. *C.R. Acad. Sci.* [*Paris*] **237**, 322–3 (*July* 27, 1953) *In French.*

Sparks between positive point and plane electrodes in compressed gases may be preceded by currents of tens of microamps at pressures of several tens of atmospheres provided sufficiently fine points are used. The currents are the result of corona discharges augmented by cold electron emission from the cathode. The latter is probably enhanced field emission due to positive ions on an insulating surface layer at the cathode. C. G. MORGAN

537.528

496. Electron avalanche in liquids at strong electric fields. C. YAMANAKA AND T. SUITA. Note in *J. Phys. Soc. Japan*, **8**, 277–8 (*March–April*, 1953).

See Abstr. 498 (1954). Results of experiments suggest that electron avalanches are the decisive cause of breakdown in strong fields. C. A. HOGARTH

537.528 : 621.3.015.5 : 621.317.333 : 621.315.615

497. The dependence of the dielectric strength of pure liquids on cathode material. T. J. LEWIS. *Proc. Phys. Soc.* [*London*] *B*, **66**, 425–8 (*May*, 1953).

The breakdown of a liquid depends entirely on its characteristics if the ionization field is such that the corresponding cathode field produces a copious emission of electrons. If, however, the ionization field is lower and breakdown is determined by the

cathode emission reaching high proportions, the cathode material will affect the result. Experiments with point-plane electrode systems of various metals indicate marked cathode-dependence when the plane is negative and in this case the materials of higher work-functions give higher breakdown voltages. Measurements with gaps of 5×10^{-3} cm between Al and Cr electrodes indicate that with the plane negative, the liquid is stressed to much higher values than those occurring with negative point breakdown long before breakdown takes place. Presumably, breakdown does not occur sooner because of the lack of electrons from the plane cathode. G. HOWELLS (R)

537.529

498. Electronic conductivities of solids in strong electric fields. I. C. YAMANAKA AND T. SUITA. Note in *J. Phys. Soc. Japan*, **8**, 274–7 (*March–April*, 1953).

To investigate the electronic part of pre-breakdown phenomena, a 7 kV, 4–1000 μsec, 10–100 cycles, generator was used for crystals of KCl, NaCl, KBr and amorphous solids such as glass. Precautions to remove heavy residual charge were taken and experiments were made to 300°C or more. In some cases evidence for field-emission of the type proposed by Schottky and Frenkel was obtained; in others Fröhlich's impurity-dominant mechanism seemed appropriate. C. A. HOGARTH

537.529

499. On the space charge effect in dielectric breakdown of KCl single crystals. Y. INUISHI AND T. SUITA. Note in *J. Phys. Soc. Japan*, **8**, 567–8 (*July–Aug.*, 1953).

The effect of d.c., pulse and h.f. (400 kc/s) voltages is studied at various temperatures. Combined pulse and d.c. voltages are used to elucidate space-charge effects. J. E. CAFFYN

X-RAYS 537.531

537.531 : 535.313

500. Theory of image formation in combinations of X-ray focussing mirrors. Y. T. THATHACHARI. *Proc. Indian Acad. Sci. A*, **37**, 41–62 (*Jan.*, 1953).

It is shown that ideally Bragg reflections can occur successively from two surfaces only if they form parts of the same sphere. However, if the aperture radius and the size of the object are small compared to the radius of curvature of the reflecting surfaces (such that fourth and higher power of their ratios are less than (10^{-6}), then the combination will work even with aspherical surfaces, provided the two reflectors are surfaces of revolution about a common axis and they are both concave reflectors having the same vertex radius of curvature and are separated by a distance equal to twice this radius. If a combination of two such mirrors is used, and N multiple reflections obtained with them, then the optical path is reduced appreciably (approximately as $1/N$) and the spherical aberration is also decreased (being proportional to $1/N$) for large magnifications. The resolving power of such a combination should be of the order of 50 Å. A combination of X-ray mirrors in the form of an X-ray microscope has, therefore, distinct advantages and it appears that the problem of realizing such a unit in practice is worth investigating. [See also Abstr. 3623 (1952)]. A.

537.531 : 535.33.07

501. A multi-wavelength fluorescence-spectrometer. I. ADLER AND J. M. AXELROD. *J. Opt. Soc. Amer.*, **43**, 769–72 (*Sept.*, 1953).

A basic multi-wavelength X-ray fluorescence spectrometer has been designed and a two-goniometer prototype built. The instrument is of the dispersive type, using separate crystals, Geiger–Müller detectors and counting circuits. The system, by providing for the simultaneous determination of more than one element, results in economy of testing time and in improved precision. Finally, an application to one type of ore analysis is described. A.

537.531 : 621.386.1

502. The operation and application of impulse X-ray tubes. R. SCHALL. *Arch. tech. Messen, Issue No.* 208 (*Ref. No. Z*74–13) 117–20 (*May*, 1953) *In German.*

A review of literature on single cold-cathode tubes, multiple beam tubes giving exposures at two or more points in rapid succession and crystallographic units passing 2000 A and giving the whole diffraction pattern in a single exposure. The chief use of such tubes is in ballistics, and the problem of film and tube protection from explosions is discussed.

F. T. FARMER

537.531 : 621.386.1

503. The development of a fine-focus flash X-ray tube. E. L. CRISCUOLO AND D. T. O'CONNOR. *Rev. sci. Instrum.*, **24**, 944–8 (*Oct.*, 1953).

Analysis of image quality indicates that a significant improvement in the technique of flash radiography might be attained through reduction of focal spot size. Existing requirements on such targets are already severe. Nevertheless it has been possible, through a novel conical design, to obtain a measured focal spot 1 millimetre square in a sealed-off flash tube operating at 100 kV. A.

537.531.08

504. A direct-reading rate meter for high-intensity penetrating radiation. J. E. MORGAN, F. W. CHAMBERS, JR, D. T. O'CONNOR AND J. T. ISTOCK. *Rev. sci. Instrum.*, **24**, 938–43 (*Oct.*, 1953).

Inherent technical difficulties in the measurement of X-ray intensities from 100 to 5000 r/min, at exciting potentials between 400 and 2000 kV peak, have been investigated. Extending the ranges of conventional condenser-electrometer dose meters by use of absorbing media not only increases energy dependence, but is also found to cause an apparent displacement in effective geometrical location of the ionization chamber. 250 r, 1000 r and 2500 r condenser chambers have proved susceptible to serious errors from dielectric leakage, which increase rapidly with chamber range above 100 r and with radiation energy above 200 kV peak. Associated measurements of voltage saturation indicate that no error from this source need be expected for full-scale exposure times exceeding 2 sec. A direct reading circuit has been developed to combine the known wavelength characteristics of "air wall" thimble-type chambers with the linear current response of a portable d'Arsonval galvanometer.

A 25 r Victoreen chamber, remotely read through lengths up to 70 ft of polyethylene coaxial cable, shows linear calibration from 35 to 5500 r/min with overall reproducibility to the order of $\pm 1 \cdot 5\%$. Ionization readings correspond, within the accuracy of chamber volume determination, to the definitive value of e.s.u./cm^2 sec. A.

537.531.08 : 539.166.08

505. Small-volume dosimeter for X-rays and gamma rays. J. H. Schulman and H. W. Etzel. *Science*, **118**, 184–6 (*Aug.* 14, 1953).

The instrument depends on fluorescence of Ag-activated phosphate glass under u.v., following exposure to ionizing radiation. The fluorescence is proportional to radiation dose, and remains > 6 months without loss, and doses down to 10 r can be detected. There is a large wavelength dependence, with max. at 60 kV. F. T. FARMER

537.531.7 : 535.43

506. X-ray scattering from a "free-volume" liquid. L. H. Lund. *J. chem. Phys.*, **21**, 1772–3 (*Oct.*, 1953).

The X-ray scattering of a monatomic liquid is calculated by averaging the intensity function over configurations of the atoms in a cellular "free-volume" configuration space corresponding to single cell occupancy. A zero-order approximation to the derived scattering equation leads to the conventional X-ray scattering equation. A slightly better approximation is also shown. A.

537.531.9 : 621.383.5

507. The X-ray photo-electric effect in barrier layer photocells. G. Blet. *J. Phys. Radium*, **14**, 368–73 (*June*, 1953) *In French.*

Describes experiments made on a selenium photocell using X-rays from a tungsten anti-cathode. A weak photoelectric effect is observed with marked fatigue. The effect of superposing a luminous flux was studied and it was found that an intense X-ray illumination markedly reduced the luminous sensitivity of the cell. A calculation of the quantum efficiency gives a large number, of the order 10^3, which is explained by the formation of an electron avalanche. A. H. W. BECK

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533

508. The design and operation of a 4·5 MeV microtron. C. Henderson, F. F. Heymann and R. E. Jennings. *Proc. Phys. Soc.* [*London*] *B*, **66**, 654–64 (*Aug.*, 1953).

The machine operates at a wavelength of 10 cm, at a magnetic field of about 1000 gauss. The diameter of the final orbit is approximately 30 cm. A circulating current of about $0 \cdot 2\ \mu$A mean has been observed at a duty cycle of 4×10^{-4}, with a 500 kW peak microwave source. A simple and efficient method of beam extraction has been developed. This has enabled a beam of semi-angles $1 \cdot 5°$ in the horizontal plane and $0 \cdot 3°$ in the vertical plane to be brought into the laboratory. It is concluded that with sufficient radio-frequency power, the output of the microtron should compare favourably with that obtainable from linear accelerators. A.

537.533

509. Crystallographic variations of field emission from tungsten. M. K. Wilkinson. *J. appl. Phys.*, **24**, 1203–9 (*Sept.*, 1953).

A photometric method has been developed and used to measure field-emission electron currents as a function of the crystallographic directions found in a W single crystal emission point. Data obtained indicate that the appearance of bright and dark areas on the pattern of a field-emission projection tube can be explained by the differences in the work functions of the various crystallographic directions. The experiments also suggest that the value of the exponent of the work function needed to relate the field-emission equation to observed data is $(\frac{3}{2})$ as predicted by theory. The method of analysis is independent of the need for high accuracy of electric field determination. However, it does depend on a knowledge of the electric field distribution about the surface of the emission point. In these experiments, the field distribution was an assumption based on experimental data. To insure the constancy of the electron emission required for measurement it was necessary to maintain an excellent vacuum. A method is given for the attainment and maintenance of a pressure in the region of 10^{-12} mm of Hg. A.

537.533.7 : 621.385.833

510. Electron flow through small tubes with magnetic focusing. J. L. Stewart. *J. appl. Phys.*, **24**, 1236–40 (*Sept.*, 1953).

When a uniform finite magnetic field passing through the cathode is used for focusing a beam of electrons, random emission at the cathode results in the electrons travelling down the beam in a helical manner. Such a rotational motion severely limits the amount of current that can be made to travel through a small tube or between closely spaced parallel plates. The amount of current transmitted through such structures is calculated and presented in the form of normalized curves. It is assumed that the current initially fills the tube or the region between the parallel plates. If an alternating electric field having a frequency comparable to the rotational frequency of the electrons is applied normal to the beam, the average electron radius of motion is increased. Should the electron beam be made to flow through a tube after the application of such an alternating electric field, the current transmission through the tube will be less than that when no electric field exists. The first-order correction term for this case is calculated and presented in the form of normalized curves. The fact that the average electron radius is increased when an electric field is present implies added energy and leads to the formulation of a conductance expression relating the power in the rotational motion of the beam to the electric field normal to the beam. The current interception and the equivalent beam conductance are important in many electronic devices such as travelling-wave tubes. The beam conductance may be of the order of that present off the axis of a helix. A.

537.533.72

511. Correction of electrostatic lenses by departure from rotational symmetry. J. C. BURFOOT. *Proc. Phys. Soc.* [*London*] *B*, **66**, 775–92 (*Sept.*, 1953).

It is known that departures from rotational symmetry may offer correction possibilities for certain aberrations which limit the resolving power of present-day electron microscopes. The geometrical optics of such departures in electrostatic systems and the general correction conditions are investigated. The minimum number of design parameters is taken, in order to ensure a simple structure, and a theory is developed for the correction of third-order spherical aberration in the particular type of objective lens evolved. This theory is simple enough for computation, yet applies to lenses with four electrodes capable of a high magnification. An example shows a tolerance of $\frac{1}{2}$ micron for the correcting electrode if the resolution limit is to be reduced to 10% of its rotationally symmetric value. A better example could probably bring this within engineering practice, but first-order astigmatic electrodes are also needed, and the tolerances of these are one or two factors of ten more exacting. It is therefore here that the difficulties will arise in the application of non-rotational symmetry. A.

537.533.72 : 517.944 : 621.385.833 : 621.317.329

512. Electrostatic potential plotting for use in electron optical systems. K.-C. HO AND R. J. MOON. *J. appl. Phys.*, **24**, 1186–93 (*Sept.*, 1953).

A non-iterative numerical method has been found for solving a partial differential equation when its boundary conditions are not known on the entirety of a closed boundary. Under such conditions, the iterative numerical methods which are generally used, such as the relaxation technique, are not applicable. As an example, this non-iterative numerical method has been used to calculate the shapes of a pair of beam forming electrodes for use in an electron gun in which rectilinear flow is desired. The calculated shapes are in almost complete agreement with Pierce's (1940) experimental results. Equipotential surfaces calculated by this method have been checked by means of an electrolytic trough which employs a semi-automatic detecting and plotting system. A.

537.533.72 : 518.5 : 621.317.79 : 621.385.833

513. An analogue computer for the study of trajectories in electron lenses. A. HAMPIKIAN. *C.R. Acad. Sci.* [*Paris*] **236**, 1864–6 (*May* 11, 1953) *In French.*

Describes a simple "transmission line analogue" calculator [see Abstr. 8430 (1950)] with which the cardinal points of a symmetrical lens have been determined to an accuracy of better than 1·5%.

G. D. SIMS (R)

537.533.72 : 518.5 : 621.317.79 : 621.385.833

514. On the correspondence between electron lenses and electric quadripoles. F. BERTEIN. *C.R. Acad. Sci.* [*Paris*] **236**, 2047–9 (*May* 27, 1953) *In French.*

See preceding abstract. Further discusses the analogy between electron lenses and electric artificial lines. G. D. SIMS

537.533.72

515. Spherical condenser type spectrometer. Y. KOBAYASHI AND G. MIYAMOTO. Note in *J. Phys. Soc. Japan*, **8**, 135–6 (*Jan.–Feb.*, 1953).

A spectrometer of 10 cm radius is described, and the results of a measurement of the conversion-line spectrum of RaD are given. J. J. WILKINS

537.533.72

516. A long lens beta ray spectrometer. M. S. MLADENOVIC. *Bull. Inst. Nuclear Sci. "Boris Kidrich,"* **3**, 69–73 (*Aug.*, 1953).

Describes an iron-free spectrometer and an electron gun with two hemispherical electrodes, which was used for its adjustment. For a source of 2 mm dia. and a solid angle of 1·4% of 4π, the resolving power of the spectrometer is 0·46%. A.

537.533.72

517. The variable-radius semicircular magnetic focusing β-ray spectrometer. C. G. CAMPBELL AND J. KYLES. *Proc. Phys. Soc.* [*London*] *B*, **66**, 911–20 (*Nov.*, 1953).

Li's method (1937) for determining the line shape in a variable-radius spectrometer is discussed, and a rapid approximate method is given. Methods of normalization for the continuous β-particle spectrum and for conversion electron lines are presented. The advantages and disadvantages of this type of spectrometer are discussed. A.

537.533.72

518. Investigations on a short magnetic lens spectrometer. M. K. BANERJEE AND A. K. SAHA. *Proc. Phys. Soc.* [*London*] *B*, **66**, 937–48 (*Nov.*, 1953).

In the course of an attempt to find reversible relations between the parameters describing the trajectory of an electron in a short magnetic lens spectrometer, it was found that the magnetic lens can be surprisingly well represented by a thick converging type optical lens which satisfies Newton's laws for the conjugate planes and the tangent relation far outside the paraxial range where the lens power calculated by the paraxial method can be in error by as much as 50%. Expressions have been obtained for the focal length as a function of the object angle and momentum of the electron. Various other properties of the lens spectrometer have been investigated. In particular, the use of a continuous baffle system to improve the resolution and line-shape for an extended source has been studied by an easy and accurate method. A.

537.533.73

519. Recent developments in electron diffraction. T. B. RYMER. *Brit. J. appl. Phys.*, **4**, 297–302 (*Oct.*, 1953).

An account is given of the electron-optical principles of simple and high-resolution electron diffraction cameras, and of the combined electron microscope and diffraction camera. Electron diffraction patterns can be used to identify materials, to determine the size, shape and orientation of crystals and to determine the orientation of large molecular groups in crystals. The patterns can also be used to study the stresses which occur naturally in many materials when the crystallites are very small. Some results of the dynamical theory of electron diffraction are stated and future applications are outlined. A.

537.533.73

520. The diffraction of 150 kV electrons. G. I. FINCH, H. C. LEWIS AND D. P. D. WEBB. *Proc. Phys. Soc.* [*London*] *B*, **66**, 949–53 (*Nov.*, 1953).

An electron diffraction camera operating at voltages up to 150 kV is described. The advantages of the use of high accelerating potentials are illustrated by results obtained with this camera. A.

537.533.74

521. The scattering of 1 MeV electrons and positrons. J. A. MCDONELL. *Austral. J. Phys.*, **6**, 245–61 (*Sept.*, 1953).

Electrons and positrons of energy 1 MeV were selected by a β-ray spectrometer and scattered by a gold foil. The scattered particles were detected by a coincidence Geiger counter arrangement, using the same geometry for electrons and positrons. The results show that the ratio of the fraction of electrons scattered through an angle θ to the fraction of positrons scattered through θ varies with θ, and the magnitudes of the ratios agree with those predicted by theory [Abstr. 7326 (1952)]. It is also inferred that there is a difference between the multiple scattering of electrons and positrons under the same scattering conditions. A.

537.533.74

522. Exchange scattering of an electron by the hydrogen atom. S. ALTSHULER. *Phys. Rev.*, **91**, 1167–71 (*Sept.* 1, 1953).

The theory of scattering of electrons by hydrogen has been re-examined with the objective of identifying the matrix element for the exchange scattered amplitude from the same integral equation which provides direct scattered amplitudes. The theory of Mott and Massey is verified, but it is demonstrated that their result contains contributions from the incident wave which must be removed before computing exchange amplitudes. The result is a theoretical justification for the Oppenheimer (prior) matrix element. A.

537.533.74

523. Complex amplitudes for electron scattering by atoms. J. A. HOERNI AND J. A. IBERS. *Phys. Rev.*, **91**, 1182–5 (*Sept.* 1, 1953).

The partial waves scattering theory has been applied to electron scattering by U and F atoms at 40 and 11 keV. The electron scattering by the UF_6 molecule, predicted from these results, is in good agreement with experiment. A.

537.533.74

524. Polarization of electrons by scattering. III. Reflection-transmission effect. N. RYU, K. HASHIMOTO AND I. NONAKA. *J. Phys. Soc. Japan*, **8**, 575–9 (*Sept.–Oct.*, 1953).

For Pt II, see Abstr. 7325 (1952). With electrons obliquely incident on a foil the intensities of the electrons scattered through a certain angle are different on the reflecting and on the transmitting side because of the plural scattering, and this phenomenon is called the reflection-transmission effect. This effect has been measured experimentally and compared with the calculation which is only a rough estimation. The experimental results obtained are in good agreement with the calculation at energies higher than 80 keV when thin gold foils are used. Since the plural scattering greatly influences the result of electron polarization experiment, the experimental results obtained previously by one of the authors (N.R.) must be corrected from this point of view. It is interesting to compare these corrected values with the theoretical ones obtained by Bartlett and Welton and recently by Mohr considering a nuclear screening by the orbital electrons, and by Bartlett and Watson using the pure Coulomb field. The agreement between experimental results and the corrected theoretical ones is not perfect, but it may be considered to be unavoidable that there are some differences between them, if one takes into account the fact that a small change in the nuclear screening makes a considerable effect on the theoretical values. A.

537.533.74

525. The effect of nuclear multipole moments on electron scattering. K. PARKER. *Proc. Phys. Soc.* [*London*] *A*, **66**, 881–4 (*Oct.*, 1953).

It is shown that possible effects of nuclear multipole moments on electron scattering are too small for measurement with the present experimental technique. A.

537.533.74 : 538.691

526. Deflection of high energy electrons in magnetized iron. S. BERKO AND F. L. HEREFORD. *Phys. Rev.*, **91**, 1127–30 (*Sept.* 1, 1953).

High-energy electrons are scattered in magnetized iron. From a shift in the multiple scattering curves due to the reversal of the magnetic field, the effective field b_{eff} acting on electrons traversing ferromagnetic media is computed. Such an effective field is dependent on the short-range forces between beam electrons and spin-aligned ferromagnetic electrons. The measurements show an effective field equal to the macroscopically measured flux density B. A.

537.533.9

527. The Cherenkov effect in optics and in the microwave region. M. ABELE. *Nuovo Cimento*, **9**, *Suppl. No.* 3, 207–13 (1952) *In French.*

An analysis is given of the conical radiation induced by a beam of electrons in a free medium with $nv/c > 1$ where v is the electron velocity and n the refractive index. This is extended to a cylindrical waveguide with a hollow cylindrical dielectric containing the axial electron beam, in which case a set of characteristic frequencies having a phase velocity equal to v is excited. With a static electric field to maintain v constant and electrons bunched at a characteristic frequency a large output should be obtained which is an amplification of the bunching signal. D. H. WHIFFEN

537.533.9

528. On the quantum theory of a luminescent electron. A. A. SOKOLOV, H. P. KLEPIKOV AND I. M. TERNOV. *Zh. eksper. teor. Fiz.*, **23**, *No.* 6 (12) 632–40 (1952) *In Russian.*

An approximate quantum theory of radiation from fast electrons moving in a magnetic field is considered. The total intensity of radiation is determined and the problems associated with the transitions between

circular and non-circular orbits are discussed in some detail. The conditions of the appearance of quantum corrections of the order $n^2/1$ are investigated, where n is the number of the radiated harmonic, and l is the azimuthal quantum number. It is shown that these corrections cancel out in the calculations of the total intensity of radiation, but the quantum corrections of the order n/l remain. E. RABKIN

537.533.9

529. Far-ultraviolet radiation from the Cornell synchrotron. P. L. HARTMAN AND D. H. TOMBOULIAN. Letter in *Phys. Rev.*, **91,** 1577 (*Sept.* 15, 1953).

Briefly reports the production, with 310 MeV (maximum) energy electrons accelerated in a circular orbit, of a strong continuum in the wavelength range 50 to 400 Å, emitted tangentially to the orbit. J. D. CRAGGS

537.534

530. How appropriate phases can be given to a number of accelerators along a closed race-track. A. J. RUTGERS. Letter in *Physica,* **19,** 548 (*June,* 1953).

It is suggested that, in a race-track using a number f of equally spaced accelerators, the frequency of oscillation in each should be f times the frequency of rotation so that all oscillators may be kept in the same phase. J. H. FREMLIN

537.534

531. The attenuation of betatron oscillations in the cosmotron. J. SEIDEN. *C.R. Acad. Sci.* [*Paris*] **237,** 240–2 (*July* 20, 1953) *In French.*

It is shown mathematically that, in the strong-focusing synchrotron, the amplitude of any initial betatron oscillations will fall off during the acceleration, being inversely proportional to the square root of the angular momentum of the particles. J. H. FREMLIN

537.534

532. A quick-change seal opener. W. R. SMITH. Note in *Rev. sci. Instrum.*, **24,** 886–7 (*Sept.*, 1953).

If the water-seals on a rotating water-cooled shaft are of the Wilson type, assembly may be difficult, as from whichever end of the water header the shaft is inserted, one of the seals is liable to be sheared off or injured. For the ORNL 86 in. cyclotron target system an arrangement is described in which a thin-walled cylinder is used to hold the seal wide open during the shaft assembly. J. H. FREMLIN

537.534 : 538.2

533. Non-linearities in the strong-focusing accelerator. E. R. CAIANIELLO. *Nuovo Cimento*, **10,** 581–93 (*May*, 1953).

The effects of the non-linearity of the magnetic field, due to the fact that it must satisfy the Maxwell equations, are estimated with particular regard to a strong-focusing accelerator. They are shown to be negligible if compared with other causes of error, so that the customary linear approximation can be safely used to discuss focusing properties. The appendix contains formulae which exhibit the symmetry properties of the magnetic field and can be used for its calculation if the pole shapes are known, or conversely. A.

537.534 : 538.2

534. Stability and periodicity in the strong-focusing accelerator. E. R. CAIANIELLO AND A. TURRIN. *Nuovo Cimento*, **10,** 594–603 (*May*, 1953).

A simple formalism is developed for the study of a strong-focusing accelerator of arbitrary geometry. It is shown to yield readily the necessary and sufficient conditions for stability and for periodicity (with any prescribed period) of the orbits. Criteria are also given which allow the determination of the range of initial conditions for which the orbits are stable. A.

537.534 : 538.2

535. Alignment errors in the strong-focusing synchrotron. M. SANDS AND B. TOUSCHEK. *Nuovo Cimento*, **10,** 604–13 (*May*, 1953).

A method is presented for the treatment of errors in alignment between the sectors of a strong focusing accelerator. Motion in one lateral co-ordinate only is treated, and the individual sectors are assumed to be ideal. It is found that if the ideal orbits (without misalignments) are periodic in one revolution the effect of the misalignments is to produce unbounded orbits, but that away from such resonances stable orbits exist. Estimates are made of the alignment tolerances required for reasonable amplitudes of the perturbed motion. The essential features of the results are independent of the detailed nature of the guide field so long as the ideal orbits are stable. A.

537.534.72

536. An electrical method of improving the resolving power of certain measurements; an application to mass spectrometry. F. BERTEIN. *C.R. Acad. Sci.* [*Paris*] **237,** 389–91 (*Aug.* 5, 1953) *In French.*

The relationship between object and image in optics is extended to electrical systems having similar laws of transmission. The resolution of certain electrical measurements may be increased by the choice of transmission characteristics. R. W. FISH

537.534.72

537. A mass spectrometer for high precision isotope ratio determinations. R. K. WANLESS AND H. G. THODE. *J. sci. Instrum.*, **30,** 395–8 (*Nov.*, 1953).

A conventional 90° mass spectrometer has been modified to permit the simultaneous collection and measurement, by means of a null method, of the ion currents due to the isotopic species of sulphur dioxide at masses 64 and 66. The design of a magnetic valve system to facilitate the rapid change from one sample to the other is described, as well as an improved ion source and collector assembly. By this method analyses may be carried out more rapidly and it has been found that the results are reproducible to $\pm 0{\cdot}02\%$ from day to day, this compares with $0{\cdot}1\%$ precision obtained with single collection methods in this laboratory. The analytical procedure is outlined. A.

537.534.74 : 778.34

538. A note on the range-scattering method of mass estimation of ionizing particles. M. G. K. MENON AND C. O'CEALLAIGH. *Phil. Mag.*, **44,** 1291–6 (*Nov.*, 1953).

The applicability of the method of Menon and Rochat [Abstr. 1066 (1952)] to the estimation of the mass of singly-ionizing particles arrested in photo-

graphic emulsion is examined and modifications necessary to take account of (*a*) dip and (*b*) the variation of scattering constant with cell-size and velocity, are discussed. The "sliding cut-off" method of eliminating large unrepresentative signals is described in detail. A.

537.534.75 : 539.164.75

539. Range-energy relations of 10- to 250-keV protons and helium ions in various gases. C. J. Cook, E. Jones, Jr and T. Jorgensen, Jr. *Phys. Rev.*, **91**, 1417–22 (*Sept.* 15, 1953).

An analysed beam of ions was brought through a differential pumping system into a low-pressure gas stopping cell, where the data necessary to plot a Bragg curve were obtained with the aid of a double grid ionization chamber of variable transverse radius. It was found that the resulting ionization extrapolated ranges may be uniquely determined only if the ionization chamber radius is greater than the transverse radius of the ionization envelope of the beam in the stopping gas. The ionization extrapolated range-energy relations for slow protons and alpha particles were determined in various gases. These data are also expressed in terms of an empirical relation. The observed range-energy relations are compared with previous data where they exist. A.

537.534.8

540. On the production of electron images from surfaces bombarded by ions. A. Septier. *C.R. Acad. Sci.* [*Paris*] **237**, 231–2 (*July* 20, 1953) *In French.*

The principle of an emission electron microscope in which secondary electrons are produced by bombardment of the object surface with ions is described. The ions may be produced by ionization of a gas or by a solid annular ion source such as a hot tungsten filament. The secondary electrons are accelerated in the same field as the ions. An image is formed by an electrostatic immersion lens. Contrast depends on variation of the secondary emission ratio over the surface. Initial results are illustrated by a micrograph magnified 200 x. A.E.I. RESEARCH LABORATORY

537.534.8

541. Electron emission from Mo by ion bombardment. J. Okano. Note in *J. Phys. Soc. Japan*, **8**, 562–3 (*July–Aug.*, 1953).

Secondary electron emission due to the incidence of positive ions (γ process) on a Mo target was measured. With A^+ ions γ increased more rapidly for an un-outgassed surface than for an outgassed one over the range 700 to 1000 eV. For a large variety of atomic and molecular ions (mass numbers up to 40) at 1000 eV γ decreased with increasing mass number. The variation of γ with different atomic ions is found to be similar to that of their ionization potential. C. G. MORGAN

DISCHARGE TUBES . COUNTERS 537.54

537.542 : 621.317.39 : 621.374.32 : 621.387.42

542. Measurement of the dead-time of a G.M. counter and of the secondary emission from the cathode by the method of delayed coincidences. E. Picard and A. Rogozinski. *J. Phys. Radium*, **14**, 445–50 (*July–Aug.–Sept.*, 1953) *In French.*

The method resembles that of Curran and Rae [Abstr. 986 (1948); *Rev. sci. Instrum.*, **18**, 871–6 (Dec., 1947)] but is simpler. The pulses from the counter are amplified, shaped and fed by two parallel paths to a coincidence counter. In one path the widths of the pulses remains constant, but in the other it may be varied. Under these conditions there will be no coincidence as long as the sum of the two widths is less than the dead time. The values obtained by this method agree with those from the *C* and *R* arrangement. A complete circuit diagram with values is given as well as an account of the theory for determining the incidence of parasitic pulses. S. C. Dunn (R)

537.542

543. Extrapolation chamber for the measurement of beta sources. R. Loevinger. *Rev. sci. Instrum.*, **24**, 907–14 (*Oct.*, 1953).

Construction and operation of a variable-spacing, parallel-plate ionization chamber is described. It has been designed for the measurement of β-particle sources of medical and biological interest. It has concentric collecting electrodes of 1, 3, 10 and 30 mm diameter. The air gap in which ionization is measured can be adjusted from 0·04 to 10 mm. Ionization current is measured with a commercial vacuum tube voltmeter which has a full-scale sensitivity of 2×10^{-13} A. The instrument sensitivity is about 0·4 e.s.u./cm^2 sec using a one mm diameter collecting electrode with a collecting air gap of 0·2 mm, and about 4×10^{-5} e.s.u./cm^2 sec using a 30 mm diameter collecting electrode with an air gap of 2 mm. Conditions are described in detail for the determination of ionization per c.c. in vanishingly-small air gaps between polystyrene electrodes, with an accuracy of a few per cent. A.

537.542 : 621.387.46

544. Design of extended-source scintillation detectors. J. D. Graves and R. H. Davis. *Nucleonics*, **11**, 49–51 (*April*, 1953).

Experiments are described, in which an extended plane light source (Pu α-particles on a ZnS screen) is viewed by a 1P21 photomultiplier, through reflecting cylinders of various lengths and diameter. The optimum conditions of cylinder length and diameter for maximizing sensitive area and counting rate are determined. Al foils around thin wall glass tubes were used as reflecting cylinders in all the tests.

L. R. SHEPHERD

537.542 : 537.525.3

545. Current fluctuations in corona counters. E. Gatti and A. Persano. Letter in *Nuovo Cimento*, **10**, 686 (*May*, 1953).

Briefly discusses a formula for the rate of change of corona current in a cylindrical electrode system, with reference to the possible use of corona discharge tubes as proportional counters. J. D. CRAGGS

537.542 : 621.318.572

546. The functioning of a special coincidence circuit. F. Demichelis and R. Malvano. Note in *Nuovo Cimento*, **9**, 1227–31 (*Dec.*, 1952) *In Italian.*

Discusses the variation of the resolving time of a

particular coincidence circuit with the energy of γ-rays, detected by scintillation counters. It is shown how this apparatus could be used for the measurement of the average energy of γ-rays. A.

537.542 : 621.318.572

547. A precision single-channel kicksorter for coincidence work. E. BREITENBERGER. *Phil. Mag.*, **44**, 987–98 (*Sept.*, 1953).

A single-channel pulse-height analyser of high speed and precision is described suitable in particular for fast coincidence experiments (resolving time 0·1 μsec). The channel width can be chosen at several values between 2 and 15 V and remains constant to better than 2 parts in 1000 over 10 hours, permitting statistically significant single counts of 10^5. The channel centre is continuously variable within a 50 V range; its r.m.s. fluctuation during 10 hours is smaller than 70 mV. A.

537.542 : 621.375.2

548. A minimal noise preamplifier for proportional counters and similar applications. K. ENSLEIN AND B. BRAINERD. *Rev. sci. Instrum.*, **24**, 916–19 (*Oct.*, 1953).

A minimal noise amplifier permitting the recognition of signals of 2μ V amplitude over a frequency range at 760 kc/s is described. The device is linear over an input range of 74 db, and is compensated for power supply potential changes by means of negative feedback. A.

537.542 : 519.282 : 578

549. On counters with random dead time. I. J. M. HAMMERSLEY. *Proc. Cambridge Phil. Soc.*, **49**, *Pt* 4, 623–37 (1953).

The problem to which the statistics of this paper relates is that of counting blood cells by an electronic-photoelectric device. The counter generates some self-paralysing impulses additional to the blood-cell impulses. Without paralysis the statistical problem is equivalent to the distribution of the number of gaps between intervals of random length distributed at random on a line. This distribution is solved by a Laplace transform method. Next a detailed theory is presented when paralysis is present. The result is a determination of the distribution of the recorded count (of blood cells) when the expected number of intervals per unit length of scan is known. The work is more complete than that of Hungarian origin.

L. S. GODDARD

537.542

550. Time analysis of Wilson cloud chamber expansions. A. B. MILOJEVIC. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **3**, 95–102 (*Aug.*, 1953).

To get a more precise time analysis of the Wilson cloud chamber expansions, characteristics of a high-speed electromagnetic valve are investigated and a method is developed for the direct measurements of the speed of the expansion. A.

537.542

551. Photoelectric detection of tracks in the diffusion cloud chamber. D. C. MARSHALL AND B. BROWN. *Rev. sci. Instrum.*, **24**, 881–2 (*Sept.*, 1953).

The experimental set-up is described from a given photograph. A photocell type RCA 926 is used, with a load of $2\times10^8\ \Omega$ to increase signal-to-noise ratio. The occurrence of a track in the cloud chamber is detected by the increase of scattered light, producing in the photocell a pulse which is amplified to trigger a photographic recorder and reset it for the next exposure. Background noise is discussed, and the possibility of more elaborate sequences triggered by the photocell are indicated. D. V. MABBS

IONIZATION . THERMIONICS 537.56/.58

537.56

552. The existence of multiply charged molecular ions of HBr, HCl, and DCl. W. H. JOHNSTON AND J. R. ARNOLD. *J. chem. Phys.*, **21**, 1499–1502 (*Sept.*, 1953).

Experimental evidence is presented for the DCl^{+1}, HCl^{+1}, DCl^{+2} and HBr^{+2} molecular ions, using a mass spectrometer. Although Cl^{+3}, Br^{+3} and A^{+3} were observed, no evidence was obtained for $H^{1,2}Cl^{+Z}$, or HBr^{+Z} above $Z = 2$. This result contradicts the recent calculations of Magee and Gurnee [Abstr. 5394 (1952)] that HBr^{+3} and HBr^{+4} would be stable toward dissociation. Finally a crude calculation is done assuming hydrogen 1*s* atomic orbitals which agrees amusingly with the experiments. A.

537.56 : 535.215

553. Photo-ionization cross section of nitric oxide. K. WATANABE, F. F. MARMO AND E. C. Y. INN. *Phys. Rev.*, **91**, 1155–8 (*Sept.* 1, 1953).

The photo-ionization cross-section of the NO molecule was measured in the spectral region 1070–1343 Å, at intervals of one to five Å, using a vacuum monochromator (band width 0·85 Å), an absorption cell with ion collector and a detector calibrated against a thermocouple. The ionization continuum showed some structure which was ascribed partly to pre-ionization of several bands in the region 1070–1150 Å and partly to vibrational levels of the ground state of NO^+ ion. The photo-ionization cross-section at Lyman α was $1{\cdot}24\times10^{-18}$ cm^2, about one-half the total absorption cross-section. The first ionization potential, $9{\cdot}23 \pm 0{\cdot}02$ eV, was obtained from the long wavelength limit of the ionization continuum. Application of the method to other molecules appears promising. A.

537.56 : 535.215

554. The photoionization of molecules in the vacuum ultraviolet. E. C. Y. INN. *Phys. Rev.*, **91**, 1194–5 (*Sept.* 1, 1953).

A method of measuring thresholds for photoionization of molecules, corresponding to the first ionization potential, is described. The method is applied to several different molecules (O_2, NO, NH_3, SO_2, C_2H_4, CH_3I, CH_3OH, C_2H_5Br). The first ionization potentials obtained are compared with those measured by other methods, e.g. electron impact and spectroscopic. The photoionization method gives greater precision than the electron impact method and is applicable to cases where the spectroscopic method fails. A.

537.561

555. Electron impact studies of the vinyl ion and radical. F. H. FIELD. *J. chem. Phys.*, **21**, 1506–10 (*Sept.*, 1953).

The appearance potentials of the vinyl ion as produced by electron impact from eight different compounds were measured. The corresponding values of the heat of formation of the vinyl ion vary from 274 to 292 kcal/mole, with an average value of $281._5$ kcal/mole. It is pointed out that no definitive explanation for the variation can be given. The heat of formation of the vinyl radical is found to be $82._3$ kcal/mole, which leads to a value of 122 kcal/mole for the first C–H bond dissociation energy in ethylene. The ionization potential of the vinyl radical is $200._5$ kcal/mole $= 8{\cdot}6_9$ eV. A.

537.561 : 539.132

556. Studies of ionization efficiency. III. The detection and interpretation of fine structure. J. D. MORRISON. *J. chem. Phys.*, **21**, 1767–72 (*Oct.*, 1953).

For Pt II, see Abstr. 6593 (1952). The effect of the spread in energy of the ionizing electron beam on the resolution of structural details in ionization efficiency curves has been evaluated, and the possibility of its removal by analytical methods is discussed. It has been shown that the first and second derivatives of the ionization efficiency possess useful properties, and that, when certain assumptions are made about the shape of the ionization probability function for a single process, a new method of measuring ionization potentials can be devised. Correlation techniques have been employed to enhance materially the signal-to-noise ratio in the output from the ion collector. Detailed measurements of the ionization efficiencies for the inert gases have been made, and the assumptions referred to are justified. It is shown that the ionization efficiencies for some molecular ions can be correlated with their vacuum ultraviolet and near X-ray spectra. It is found that competition occurs between all possible processes of excitation and ionization at each level of energy. The higher energy levels of molecules can be studied and, in principle, an unequivocal assignment of bond dissociation energies from mass spectrometric data is possible. A.

537.564

557. Oscillations in space charge detectors and the ultra-ionization potentials of mercury. O. M. WHITE. *Proc. Phys. Soc.* [*London*] *B*, **66**, 642–8 (*Aug.*, 1953).

Experiments were carried out on the probability of ionization of mercury by electron impact, using an electron gun and space charge detector. Some irregularities in the curve obtained for the variation of probability with electron energy were found to be associated with instability and oscillations in the detector. These appear to arise from a periodic rearrangement of space charge. The results show that under certain conditions the response of a space charge detector can be non-linear and that it can give spurious effects which might be misinterpreted as marking the onset of new ionization processes. A.

537.583 : 621.385.032.216

558. Space charge effect in the oxide cathode layer. II. T. SHINDO. *J. Phys. Soc. Japan*, **8**, 494–9 (*July–Aug.*, 1953).

For Pt I, see Abstr. 3671 (1952). In the previous paper it was pointed out that space charge may be formed in the oxide cathode layer and the Schottky behaviour of the oxide cathode can be well understood as an effect of this space charge. In this paper the theory was extended to the retarding field region and the complete static character of a planar diode was calculated, with some amendment of the theory. In an accelerating field the static character of the diode depends decisively on the space charge effect in the cathode layer. In a retarding field, however, the space charge has little effect on the static character but the amount of the space charge varies considerably with anode voltages. A.

COSMIC RAYS 537.591

537.591.1

559. On the mesonic component of the cosmic radiation. G. WATAGHIN. *Nuovo Cimento*, **9**, *Suppl. No.* 2, 102–7 (1952) *In Italian.*

An elementary review. L. PINCHERLE

537.591.1

560. High altitude balloon experiments and measurement of the heavy primary radiation flux at the geomagnetic equator. H. J. TAYLOR, M. SITARAMASWAMI AND P. N. KRISHNAMOORTHY. *Proc. Indian Acad. Sci. A*, **36**, 41–54 (*July*, 1952).

The behaviour of balloons is discussed, and it is shown that systems of balloons may have a series of stable floating levels at determinate altitudes. A magnetic orientating unit was used. Analysis of the tracks observed in the plates has given the following values for the primary cosmic-ray flux at the geomagnetic equator: for $6 \leqslant Z \leqslant 10$, $N_0 = 1{\cdot}45 \pm 0{\cdot}30$ particles/m^2. sec. sterad; for $Z > 10$, $N_0 = 0{\cdot}33 \pm 0{\cdot}08$ particles/m^2.sec. sterad. Any observable EW asymmetry at the heights reached by the plates is within the statistical uncertainty of the results. The charge spectrum is in general similar to what has previously been observed. A.

537.591.1

561. Cosmic rays underground. B. V. SRIKANTAN AND S. NARANAN. *Proc. Indian Acad. Sci. A*, **36**, 97–117 (*Aug.*, 1952).

An investigation on cosmic-ray intensity carried out in the gold mines at Kolar (Mysore State), with a hodoscoped counter telescope, up to a depth of 1008 m water equivalent. Conclusions are as follows: (1) The intensity-depth curves for particles penetrating $2{\cdot}5$ cm and 10 cm lead, run parallel between 500 and 1008 m water equivalent. (2) The vertical intensity of penetrating particles in terms of particles cm^{-2} sec^{-1} sterad^{-1} can be expressed by the power law $I_V = 10^{3.56} H^{-3{\cdot}1 \pm 0{\cdot}1}$ for $500 \leqslant H \leqslant 1008$ m w.e. (3) The flux values for the penetrating component obtained are higher than those of the total component given by Wilson, by a factor 2, at all depths between 500 and 810 m w.e. Flux values for the penetrating component are higher than the corresponding flux values

of Clay and Gemert by a factor 4·5. Surface value of flux is in agreement with the surface values of Wilson, Clay and Gemert. (4) The angular distribution follows approximately $\cos^3$ law at 22 m w.e. and $\cos^4$ law at 598 m w.e. (5) The secondary production by μ-mesons in the lead of the apparatus, as well as the soft component in equilibrium with the hard component, increases with depth. The experimental values giving the proportion of soft component in equilibrium with the penetrating component, agree well with the theoretical calculations of Hayakawa and Tomonaga. (6) Assuming that all the μ-mesons observed underground are produced only as a result of the decay of π-mesons, the value of exponent in the differential spectrum of π-mesons at production in the energy range $200 < E < 450$ BeV, is found to be 2·4. (7) The experimentally determined μ-meson integral spectrum in the energy range $150 < E < 300$ BeV is given by $N_\mu(>E) = 0{\cdot}664E^{-2{\cdot}09\pm0{\cdot}02}$. (8) The neutral radiation underground is essentially of radioactive origin. A.

537.591.1

562. Energy balance of the cosmic radiation. G. Puppi. *Nuovo Cimento*, **10**, *Suppl. No.* 2, 115–46 (1953) *In Italian.*

A new detailed assessment of the energy balance at 50°N latitude. The incident flux appears still to be about 15% higher than the total power loss deduced from ionization chamber data or 25% higher than that deduced from counter data, but, given the many causes of uncertainty, the discrepancy may not be significant. The better agreement with respect to previous estimates of the balance is due mainly to a better definition of the intensity of the various secondary components and to a more detailed examination of low energy phenomena. It is interesting that over one-quarter of the energy is dissipated by neutrinos. L. PINCHERLE

537.591.1

563. Some K-particle mass measurements. D. M. Ritson. Letter in *Phys. Rev.*, **91**, 1572 (*Sept.* 15, 1953).

Gap density measurements on three K-particles leads to mass values of 970, 1010 and 870 m_e. The error in each case is $\pm 100\, m_e$. H. ELLIOT

537.591.15

564. Production and interaction of mesons at very high energies. D. Lal, Y. Pal, B. Peters and M. S. Swami. *Proc. Indian Acad. Sci. A*, **36**, 75–96 (*Aug.*, 1952).

A shower containing ~360 charged and neutral shower particles produced by a magnesium nucleus of 2×10^{14} eV provided a source of mesons whose interactions have been studied over an aggregate track length of about 3 m in emulsion. It is first shown that in very large showers not only the incident energy can be determined but also the energy of the shower particles. The angular distribution of the shower particles agrees closely and their multiplicity is consistent with Fermi's theory. It is shown that the interaction cross-section of charged shower particles is geometric and that at an energy $\varepsilon \sim 1000\,\mu c^2$ they produce on the average 5 to 6 mesons. The mesons are preferentially emitted in the backward direction in the reference system in which the momentum of the incident meson balances that of a nucleon in the target. The excitation produced in the target nucleus is much lower than in nucleon-produced showers of comparable multiplicity. The charged mesons are not emitted in pairs by a heavier meson of short lifetime. Charged shower particles as well as electrons produce electron-positron pairs with a cross-section of the order of that predicted by theory. The number of neutral mesons decaying into γ-rays in a time $\leqslant 10^{-14}$ sec is nearly equal to the number of charged shower particles. Evidence exists for the emission of neutral particles, different from neutrons, capable of producing meson showers. The energy balance of the event suggests that a few shower particles carry an appreciable fraction of the total energy. A.

537.591.15

565. On the penetrating component in air showers. B. Chowdhuri, R. C. Saxena and A. Subramanian. *Proc. Indian Acad. Sci. A*, **36**, 457–71 (*Dec.*, 1952).

The penetrating particles in extensive showers are shown to be of two types. A large proportion show an interaction with nuclei. The relative abundance of the non-interacting component in air showers is found to ~0·7% for showers of primary energy $\sim10^{15}$ eV at about 10 m from the cores of the showers at sea level. There is also evidence for the presence of an appreciable percentage of the particles showing interaction with nuclei even at sea level. This indicates the occurrence of cascades of nuclear collisions. The N-component capable of producing penetrating showers of at least two ionizing secondaries (with minimum total kinetic energy of the secondaries ~1·7 BeV) is found to be 29% as great as that of the non-interacting penetrating particles, whereas the ratio of the N-component μ-mesons, considering all low-energy events (energy ~1 BeV) is of the order of 0·88. This shows that a large number of N-particles of low energy exists in air showers at sea level. On comparing results with those of other workers recording showers of lower initial energies at mountain altitudes, it is found that the ratio of μ-mesons to electrons is practically identical for all these showers while the ratio of the N-component to μ-mesons decreases from 62% to 29% over an energy range 10^{13} to 10^{15}eV between the atmospheric depths of 600 g/cm^2 and sea level. This decrease of the N-component with increasing atmospheric depth is much smaller than that expected due to simple attenuation of the N-component in the atmospheric length traversed between these two levels. A.

537.591.15

566. A note on the lateral spread of high energy showers. G. Poiani and C. Villi. *Nuovo Cimento*, **10**, 179–81 (*Feb.*, 1953) *In Italian.*

Theoretical. A table is given of the calculated mean square angle and mean square deviation as a function of the energy. L. PINCHERLE

537.591.15

567. On the penetrating shower originating in light element and heavy element. S. Higashi, T. Kitamura, T. Kubozoe, M. Oda, S. Ozaki and Y. Watase. *J. Phys. Soc. Japan*, **8**, 584–9 (*Sept.–Oct.*, 1953).

Comparison was made of penetrating showers originating in carbon and lead. Using the counter

hodoscope and the Wilson cloud chamber, the multiplicity of the penetrating shower and the absorption of the shower particle and the secondary event produced by the shower particle were observed. Consequently different energy spectra at lower energy and its equality at higher energy of the shower particles for different sizes of the mother nucleus were tentatively assumed and discussed. A.

537.591.3

568. The absorption mean free path of the high-energy nucleonic component of cosmic radiation. M. F. Kaplon, J. Z. Klose, D. M. Ritson and W. D. Walker. Letter in *Phys. Rev.*, **91**, 1573 (*Sept.* 15, 1953).

Two similar emulsion cloud chambers, one exposed for 30 days at 10 700 ft and the other for 6 hours at 90 000 ft, were used for flux measurements of the nuclear interacting component of cosmic radiation at energies $\geqslant 10^{12}$ eV. Comparison of the flux values leads to an absorption mean free path of 129 ± 15 g.cm^{-2} and a primary flux of $0{\cdot}22 \pm 0{\cdot}075$ per m^2.sec.steradian. H. ELLIOT

537.591.5

569. On the diurnal variation of cosmic rays. I. The disturbance in cosmic-ray diurnal variation. Y. Sekido and S. Yoshida. *Rep. Ionosphere Res. Japan*, **4**, *No.* 1, 37–42 (1950).

The diurnal variation undergoes a characteristic increase of amplitude at the same time as or immediately after magnetic storms, recovering after a few days. Also the time of maximum intensity is advanced in magnetic storms, showing a similar variation as that of the decrease of daily mean cosmic ray intensity.

G. M. BROWN

537.591.5

570. Increase of cosmic ray intensity at sea level during sand storms. M. Abd El-Wahab, L. Allegretti, M. G. El-Fandi and M. El-Sherbini. Letter in *Nuovo Cimento*, **9**, 734–5 (*Aug.*, 1952) *In Italian.*

Increases up to 30% were observed at Alexandria (Egypt) both for the hard and the soft component, and found to be correlated to the velocity of the wind.

L. PINCHERLE

537.591.5

571. Meteorological and extra-terrestrial causes of the daily variation of cosmic ray intensity. V. Sarabhai, U. D. Desai and R. P. Kane. *Proc. Indian Acad. Sci. A*, **37**, 287–303 (*Feb.*, 1953).

The daily variations of total cosmic-ray intensity and the intensities of meson and electron components have been studied at Ahmedabad with vertical Geiger counter telescopes. It has been found that appropriate barometric coefficients for correcting the cosmic-ray intensities can be obtained from a consideration of the semidiurnal components of the variations. The barometric coefficients for the three intensities are $\beta_T = -4{\cdot}2\%$ per cm Hg, $\beta_M = -2{\cdot}4\%$ per cm Hg, $\beta_E = -14{\cdot}0\%$ per cm Hg. The cosmic-ray intensity variations are corrected with the appropriate coefficients for the daily variation of barometric pressure. No significant variation is then left in the electron intensity, implying that variations of this component are mostly caused by the mass absorption effect with a variation of barometric pressure. In total intensity and in meson intensity, on the other hand, there is a significant residual variation of about 0·3% in amplitude. This is mainly diurnal in character with a maximum at 0900 hours I.S.T. Reasons are given for concluding that the meson residual variation is not primarily caused by either the diurnal variation of temperature in the atmosphere or of geomagnetic elements. It is finally concluded that the bulk of the meson residual diurnal variation is extra-terrestrial in origin and is caused by continuous solar emission of cosmic-ray particles. This conclusion is discussed in terms of the interpretation of omnidirectional and unidirectional measurements of the diurnal variation by other workers. A connection between changes in the amplitude and the hour of maximum of the diurnal variation is suggested. A.

537.591.5

572. East-west asymmetry of cosmic rays. D. S. R. Murty. *Proc. Indian Acad. Sci. A*, **37**, 317–20 (*Feb.*, 1953).

A triple coincidence counter telescope has been employed for the study of the east-west asymmetry of cosmic rays at Hyderabad, India ($\lambda = 7{\cdot}7°$; $h = 1800$ ft). The telescope, subtending an angle of 15·6° in the plane of rotation, was mounted on a light wooden frame capable of rotation about horizontal and vertical axes. Asymmetry measurements were made at a number of zenith angles with an interval of 15°. The asymmetry rose to a maximum of 12·3% at a zenith angle of 43° and fell off at higher angles. The results are in general agreement with some of the other workers. A.

537.591.5

573. The cosmic ray intensity above the atmosphere near the geomagnetic pole. J. A. Van Allen. *Nuovo Cimento*, **10**, 630–47 (*May*, 1953).

With the help of new high-altitude intensity measurements of Meredith, Van Allen and Gottlieb with single Geiger counters near the north geomagnetic pole, an assessment of existing knowledge of the low rigidity end of the primary cosmic-ray spectrum is presented. The new Iowa rocket experiments fully confirm and substantially extend previous evidence for the marked flattening of the integral primary cosmic-ray spectrum below a magnetic rigidity of about $1{\cdot}5 \times 10^9$ volts. In particular, they indicate a complete or nearly complete absence of the major components (H, He) of the primary radiation in the following spectral regions: (*a*) For hydrogen, the magnetic rigidity range $1{\cdot}2 \times 10^9$ volts to $0{\cdot}18 \times 10^9$ volts (kinetic energy range 590 MeV to 18 MeV). (*b*) For helium, the magnetic rigidity range $1{\cdot}2 \times 10^9$ volts to $0{\cdot}37 \times 10^9$ volts (kinetic energy range 700 MeV to 72 MeV). The low end of these ranges is far below that attainable by any means except rocket-borne apparatus. This observed absence of low rigidity primaries is not inconsistent with a solar dipole moment as large as $0{\cdot}6 \times 10^{34}$ gauss.cm^3. But there may be an entirely different physical cause. Due to the low relative abundance of primary nuclei of $Z > 2$, the present data are not of sufficient accuracy to conclusively exclude their presence in the low rigidity region of the spectrum. A crucial test of the solar cut-off hypothesis is available in this connection. Preliminary rocket

flights of pulse ionization chambers have been made with the intention of investigating the intensities of low rigidity heavy nuclei. A.

537.591.8

574. On the anomalous distribution of disintegration stars produced by the cosmic radiation in photographic emulsions. L. B. Silva, C. Bonacini, C. Depietri, G. Lovera and E. P. Fedeli. Letter in *Nuovo Cimento*, **9**, 630–2 (*July*, 1952) *In Italian.*

A statistical analysis of 1359 stars has shown that there is no ground for asserting that the number of pairs of stars, whose centres are at a distance less than 1·5 mm in plates of 100 μ thickness, is much larger than one would expect on the basis of a random distribution. L. PINCHERLE

537.591.8

575. On the anomaly in the intrinsic angular distribution of the prongs in stars produced by cosmic rays. G. Lovera. Letter in *Nuovo Cimento*, **9**, 857–60 (*Sept.*, 1952) *In Italian.*

The anisotropy previously demonstrated in 3 or 4 prongs stars [Abstr. 2823 (1952)] has been found, in an attenuated form, in 5 prongs stars, from a statistical analysis of 125 events (625 angles). It disappears in stars with a larger number of prongs. L. PINCHERLE

537.591.8

576. A search for the production of penetrating secondaries by μ-mesons underground. A. Lovati, A. Mura, C. Succi and G. Tagliaferri. Letter in *Nuovo Cimento*, **10**, 105–7 (*Jan.*, 1953).

This has been investigated using a multiplate cloud chamber under 55 m water equivalent of granite at altitude 200 m. No example of penetrating secondary production was found in a total path length of 352 m lead. H. ELLIOT

537.591.8

577. Observation of the decay at rest of a heavy particle. A. Bonetti, R. L. Setti, M. Panetti and G. Tomasini. Letter in *Nuovo Cimento*, **10**, 345–7 (*March*, 1953).

Discusses an event observed in G5 nuclear plates exposed for 2 hr at 20 000 m. A heavy particle stopped in the emulsion, giving rise to a fast secondary. Scattering-range measurements lead to a mass value of 2500 $\pm$ 345 m_e for the primary. It has not been possible to identify the secondary. H. ELLIOT

537.591.8

578. On a recent interpretation of star data. H. Messel and R. B. Potts. Letter in *Nuovo Cimento*, **10**, 496–7 (*April*, 1953).

Points out that the results of Cortini *et al.* [Abstr. 7780 (1953)] on stars observed in emulsions can be explained on the basis of plural meson production, contrary to the conclusions of those authors. H. ELLIOT

537.591.8

579. New evidence concerning extreme energy interactions in heavy nuclei. C. B. A. McCusker and F. C. Roesler. Letter in *Phys. Rev.*, **91**, 769 (*Aug.* 1, 1953).

A comparison of the mean multiplicity predicted by the authors' theory [Abstr. 7783 (1953)] with the measurements of Kaplon, Ritson and Walker [Abstr. 311, 6127 (1953)] on G-5 emulsions, Cu and Pb suggests that at 5×10^{12} eV true multiple production takes place. W. J. SWIATECKI

537.591.8

580. Interpretation of $0 + xp$ type stars in photographic emulsions. C. B. A. McCusker and F. C. Roesler. Letter in *Phys. Rev.*, **91**, 769 (*Aug.* 1, 1953).

It is suggested that stars which are initiated by a fast singly charged particle and which consist only of a number of "shower" particles are due to a normal cascading through the nucleus and not to a single nucleon-nucleon interaction as previously supposed. A. C. COATES

537.591.8

581. Recent experimental results on *S*-particles. H. Bridge, H. Courant, H. DeStaebler, Jr and B. Rossi. Letter in *Phys. Rev.*, **91**, 1024 (*Aug.* 15, 1953).

Further cloud chamber photographs of S-particles decaying into a charged secondary and sometimes also a neutral producing an electron cascade indicate that the decay does not always give rise to photons of energy >150 MeV. [See Abstr. 6122 (1953).] W. J. SWIATECKI

537.591.8

582. Interpretation of cosmic ray jets. W. Heitler and C. Terreaux. *Proc. Phys. Soc.* [*London*] *A*, **66**, 929–39 (*Oct.*, 1953).

Cosmic-ray jets are interpreted as being due to the creation of a more or less cylindrical penetration tunnel in the nucleus. An estimate of the energy transfer to the residual nucleus is made and it is shown that this arises mainly from the surface energy of the tunnel. The order of magnitude found accounts for the relatively small number of heavy tracks N_H observed. The fluctuations of N_H are also in rough agreement with the observations. The variation of the shower size n_s is largely due to the variation of the tunnel length d, but there are also substantial fluctuations of n_s for a given d. The upper limit of n_s is due to the maximum tunnel length in AgBr, and is, above a certain energy, independent of the primary energy. The values of n_s can be obtained (in agreement with the facts) from a purely plural or a suitable mixed plural-multiple model for meson production. A.

537.591.8

583. Example of a V^+ decay. R. W. Thompson, A. V. Buskirk, C. J. Karzmark and R. H. Rediker. Letter in *Phys. Rev.*, **92**, 209 (*Oct.* 1, 1953).

A heavily ionizing particle of momentum 270 $\pm$ 10 MeV/c appears to decay in flight in the chamber producing a secondary of minimum ionization. The event is analysed in detail and it is concluded that the mass of the primary lies between 940 and 1200 m_e. An upper limit of 740 m_e is obtained for the mass of the secondary. H. ELLIOT

MAGNETISM 538

538.082

584. An improved Rankine magnetic susceptibility balance for use in free radical determinations. J. O'M. Bockris and D. F. Parsons. *J. sci. Instrum.*, **30**, 362–3 (*Oct.*, 1953).

Practical details are given for the construction of an improved Rankine magnetic susceptibility balance

suitable for determinations of free radicals of lifetime longer than 1 min and in concentrations greater than 0·0004M. A.

538.082.74 : 621.317.444

585. A small sensitive magnetometer. T. M. PALMER. *Proc. Instn Elect. Engrs II*, **100**, 545–50 (*Oct.*, 1953).

A magnetometer is described which was designed primarily for measuring a magnetic field within the confined space of a permeameter. The measuring head of the instrument contains a thin solenoid through which a direct current is passed, to balance the field being measured and produce zero field in the solenoid. A sensitive field detector within the solenoid consists of a fine ferromagnetic (Mumetal) wire carrying an alternating current of frequency 5 kc/s. This current develops a saturating circular field in the wire and causes its effective longitudinal permeability to alternate at twice the frequency of the current. A field along the wire thus produces an alternating induction in the wire and consequently an alternating e.m.f. in the solenoid; this e.m.f. therefore serves as a sensitive indication of field. With associated equipment designed especially for the magnetometer it is possible to detect a change in field strength of 2×10^{-5} oersted. Alternatively the head can be used with standard laboratory equipment allowing a field of 2×10^{-3} oersted to be detected. The maximum field strength that can be measured is limited to about 50 oersteds by the heat developed in the solenoid by the balancing current. A.

538.114

586. A two-electron example of ferromagnetism. J. C. SLATER, H. STATZ AND G. F. KOSTER. *Phys. Rev.*, **91**, 1323–41 (*Sept.* 15, 1953).

The problem of two holes in an otherwise filled band, or two electrons in an empty band, is studied by the method of configuration interaction, using Wannier functions, asking which state lies lower, the triplet or singlet. If the triplet lies lower, it would indicate that the spins set themselves parallel, favouring ferromagnetism. It is found that if the band is nondegenerate, the singlet will always lie lower, so that ferromagnetism requires a degenerate band, such as the fivefold degenerate *d* band. With a degenerate band ferromagnetism can arise under some circumstances, provided the band is not too broad. The cause of the ferromagnetism is an intra-atomic exchange effect, causing the two electrons or holes to prefer to align themselves with parallel spin when they happen to lie on the same atom. The model leads to a treatment of correlation, showing that with increasing interatomic distance the likelihood of finding the two electrons or holes on the same atom decreases, vanishing at infinite internuclear distance. The ferromagnetic interaction depends both on an intra-atomic exchange integral, which persists to infinite distance, and the probability of finding the electrons or holes on the same atom, which vanishes in the limit. A.

538.114 : 530.162

587. Statistics of the three-dimensional ferromagnet. III. Some numerical results. D. TER HAAR. *Physica*, **19**, 611–14 (*July*, 1953).

For Pt II, see Abstr. 2535 (1953). The equations previously derived are used to calculate numerically the values of the configurational energy and specific heat of a simple cubic ferromagnet at temperatures above the Curie point. The specific heat curve obtained in this way is compared with the specific heat curves obtained from Bethe's first approximation and the curve obtained from the exact series expansion by a method due to Trefftz. [Abstr. 7401 (1950).] A.

538.114 : 539.11

Use of non-orthogonal wave functions in the treatment of solids, with applications to ferromagnetism. *See Abstr.* 638

538.221/.222

588. Magnetic properties of some [metal] bisulphides. L. NÉEL AND R. BENOIT. *C.R. Acad. Sci. [Paris]* **237**, 444–7 (*Aug.* 17, 1953) *In French.*

Reports results of susceptibility measurements on the substances MS_2(M = Mn, Fe, Co, Ni). CoS_2 is ferromagnetic below 110°K and the magnetic changes over the range 20° to 1000°K were investigated. The results are discussed on the basis of the assumed electronic structure and the magnitude of the interatomic distance. E. P. WOHLFARTH

538.221

589. On the influence of the external magnetic field on the activity of ferromagnetic catalysts. External magneto-catalytic effect. I. E. JUSTI AND G. VIETH. *Z. Naturforsch.*, **8a**, 538–46 (*Sept.*, 1953) *In German.*

J. A. Hedvall discovered "internal" magneto-catalytic effects [*Z. phys. Chem. A*, **209**, 445 (1935)], the activity of ferromagnetic catalyst changes upon transgressing the Curie-interval. The present paper deals with finding an "external" magneto-catalytic effect consisting of the influence of external magnetic fields upon the activity of ferromagnetic catalysts. This can be shown quite clearly in capillaries of high purity ferromagnetic nickel by experiments applying the *o-p*-hydrogen conversion. In this reaction the conversion rises so steeply with relatively low field strengths that even the magnetic earth field should enhance the catalytic activity of nickel in compact form: a few hundred oersted may suffice for doubling the conversion and at some 1000 or 10 000 oersted a saturation value of the conversion is reached. The connection between catalytic activity and magnetism finds further support by a corresponding catalytic retentivity. From the theory of ferromagnetism, especially the studies of Néel, it is known that extremely small ferromagnetic particles of the order of magnitude of Blochs walls, i.e. some 10^{-4} mm, possess high permanent magnetism. This fact appears significant in this connection for the high catalytic activity of finely divided powder catalysts such as Raney catalysts. This permanent magnetism explains also the apparent lack of the external magneto-catalytic effect when using a nickel powder catalyst. The theoretical treatment of the results cannot yet give a definite explanation; before this can be given the experiments must be extended to ordinary chemical reactions. To this end the prerequisites for such experiments are being established. Independently thereof the experimental proof for the external catalytic effect serves to ascertain that the

internal Hedvall effects are primarily correlated to the ferromagnetic and paramagnetic states of matter. A.

538.221

590. On the nature of ferromagnetism in pyrrhotite. K. Alexopoulos and A. Theodossiou. *Proc. Phys. Soc.* [*London*] *B*, **66**, 753–9 (*Sept.*, 1953).

The *g*-value of 0·63 for pyrrhotite indicates that there is a large contribution to the magnetization from orbital moment. The electron density distribution will therefore depend on the direction of magnetization, and the intensity of X-ray reflections from a suitable plane might be expected to show a detectable dependence on this direction. Inglis showed in 1934 that the *g*-value was consistent with the "carrier" being a *d*-electron with $m_l = +2$, $m_s = -\frac{1}{2}$. On this assumption calculations have been made of the electronic and atomic form factors (for one effective *d*-electron per atom) and of the structure factors for reflection on the (110) plane for magnetization normal and parallel to this plane. Although the electronic form factor in the first case is nearly twice as great as in the second, the final calculated difference in intensity is only about 0·83%. A long series of careful intensity measurements has been made, using ionization chamber methods, and the experimental result for the difference is $0{\cdot}30 \pm 0{\cdot}15\%$. It is thus shown experimentally that either there is no change in charge distribution with direction of magnetization in pyrrhotite, or the change is much smaller than that indicated by theoretical calculations for the simplest type of model consistent with the experimental *g*-value. A.

538.221

591. Ferromagnetic resonance in colloidal suspensions. D. M. S. Bagguley. Note in *Proc. Phys. Soc.* [*London*] *A*, **66**, 765–7 (*Aug.*, 1953).

Measurements made on colloidal suspensions of Fe, Co and Ni are used to show that the particles are spherical in so far as microwave resonance is concerned. The method is applied to the investigation of ferromagnetic alloy systems over a range of electron concentrations and at various temps. Results are given for a series of Ni–Fe alloys at 3·14 cm wavelength, the colloids being obtained by high frequency arc discharge in hydrogen. The *g*-value changes rapidly for the range of alloys 30% to 50%, falling sharply to a value of 2·01 at 40% Ni. G. F. Hodsman

538.221

592. Sublattice effects in magnetic resonance. R. K. Wangsness. *Phys. Rev.*, **91**, 1085–91 (*Sept.* 1, 1953).

The resonance frequencies of a system containing two or four magnetic sublattices with different gyromagnetic ratios are calculated. It is found that in many cases the results reduce to the standard formulae of ferromagnetic and antiferromagnetic resonance; they are stated, however, in terms of an effective gyromagnetic ratio equal to the quotient of the net magnetic moment and the net angular momentum of the system. Line splitting due to the existence of several normal modes of nearly equal frequencies, and the effect of the sublattice structure upon the anisotropy contribution to the line width are also discussed. The calculated values of effective *g*-values and line widths as a function of composition are compared with the experimental results for the nickel ferrite-aluminates. A.

538.221 : 550.38

593. Origin of reverse thermo-remanent magnetism of igneous rocks. T. Nagata, S. Akimoto and S. Uyeda. Letter in *Nature* [*London*] **172**, 630–1 (*Oct.* 3, 1953).

Further results have been obtained for the lava of Mt. Haruna [Abstr. 5192 (1952)] by measuring the temperature dependence of the saturation magnetization of the ferromagnetic grains contained in the rocks. The results are discussed on the basis of Néel's theory [Abstr. 6912 (1952)]. E. P. Wohlfarth

538.221 : 621.318.12 : 621.318.2

594. A new permanent magnet [material made] from powdered manganese bismuthide. E. Adams. *Rev. mod. Phys.*, **25**, 306–7 (*Jan.*, 1953).

Gives further experimental details and magnetic data for the material "Bismanol" [see Abstr. 320 (1953)]. E. P. Wohlfarth

538.222

595. Paramagnetic resonance in some cupric salts. S. Ramaseshan and G. Suryan. *Proc. Indian Acad. Sci. A*, **36**, 211–16 (*Sept.*, 1952).

Paramagnetic resonance absorption of 3 cm waves in eleven copper salts was studied. Of these, four showed paramagnetic absorption; *g*-factors and half-widths obtained are given. Single crystals of cupric ammonium chloride and cupric ammino-nitrate were studied for anisotropy in *g*-factor and line-shape parameters. Results regarding cupric ammonium chloride indicate that exchange interaction may not be isotropic. A.

538.222

596. Paramagnetic resonance absorption of Mn^{++} impurity in salts of Ni^{++}, Co^{++} and Fe^{++}, and spin-lattice relaxation. K. Ōno and I. Hayashi. Note in *J. Phys. Soc. Japan*, **8**, 561–2 (*July–Aug.*, 1953).

Describes experiments on the resonance absorption spectrum of Mn ions present as impurities in Ni, Co and Fe Tutton salts, and interprets the results. E. P. Wohlfarth

538.222

597. Temperature effect on the paramagnetic resonance in crystals. K. Kambe and T. Usui. *Progr. theor. Phys.*, **8**, 302–16 (*Sept.*, 1952).

Temperature effect, through Boltzmann distribution, on the position and the shape of paramagnetic resonance lines is studied on the assumption that the lattice structure is rigid. General formulae for the moments of any order are derived in the form of traces which can be interpreted physically as temperature averages of the quantities represented by the relevant operators. The explicit expressions for the zero-th, the first and the second moments are given on the basis of the one-ion approximation for the density matrix involved in the temperature average. As examples, applications of the formulae to the case of electronic-paramagnetic resonance in the system of equivalent free ions and to that of nuclear-paramagnetic resonance in electronic-paramagnetic crystals are discussed. A.

538.222

598. Paramagnetic resonance in *N*- and *P*-type silicon. F. K. Willenbrock and N. Bloembergen. Letter in *Phys. Rev.*, **91**, 1281 (*Sept.* 1, 1953).

Reports independent measurements [Abstr. 6775 (1953)] at 78°K and at a frequency 9 kMc/s. The *g*-factor for both holes and electrons was found to equal 2·00. The intensity of the absorption peak was found to be roughly proportional to the impurity concentration (5×10^{17} to 5×10^{18}). E. P. WOHLFARTH

538.222

599. Paramagnetic absorption curves of copper salts at different temperatures. M. B. P. Vittorelli, M. U. Palma, D. Palumbo and M. Santangelo. *Ricerca sci.*, **23**, 1423–31 (*Aug.*, 1953) *In Italian.*

Description of an apparatus devised at the Institute of Physics of the Palermo University, for the study of paramagnetic absorption by means of microwaves of the 3 cm band. The whole apparatus was tested by replotting the already known absorption curves of $CuCl_2.2H_2O$, $CuSO_4.5H_2O$, $Cu(NH_4)_2Cl_4.2H_2O$. After a brief reference to theoretical results, those obtained by means of the measurements taken at room temperatures on $Cu(NH_4)_2(SO_4)_26H_2O$ are reported. These results, together with the already known and recorded readings, complete the group of the four copper salts: sulphates and chlorides with or without ammonium. A difference was found between the already known and redetermined $CuSO_4.5H_2O$ curve at room temperature and the analogous curve at liquid air temperature. A.

538.222

600. Paramagnetism in a thermochromic compound. W. G. Nielsen and G. K. Fraenkel. Letter in *J. chem. Phys.*, **21**, 1619 (*Sept.*, 1953).

Paramagnetic resonance and a new coloration are observed in bianthrone crystals after heating to 265°C. Resonance is also observed for bianthrone in solution in decalin and in dimethylphthalate over the range 140–200°C with similar *g*-factor and line width. There is no indication of a triplet state for the paramagnetic form as concluded previously from spectroscopic data [W. T. Grubb and G. B. Kistiakowsky, *J. Amer. Chem. Soc.*, **72**, 419 (1950)]. C. F. J. GARLICK

538.222

601. The shape of exchange narrowed paramagnetic resonance lines. R. T. Weidner and C. A. Whitmer. Letter in *Phys. Rev.*, **91**, 1279 (*Sept.* 1, 1953).

It is shown that in diphenyl picryl hydrazyl powder at 4·2°K when exchange narrowing is important, the paramagnetic resonance line follows closely the shape $(1+x^2)^{-1}$ with $x=2(H-H_0)/\Delta H$ and $\Delta H=3\cdot64\pm0\cdot04$ oerst. $g=2\cdot0025\pm0\cdot0003$. At room temperature the shape is similar with $\Delta H=2\cdot70$ oerst. D. H. WHIFFEN

538.222

602. Paramagnetic resonance in palladium and platinum group compounds. J. H. E. Griffiths, J. Owen and I. M. Ward. *Proc. Roy. Soc. A*, **219**, 526–42 (*Oct.* 7, 1953).

The paramagnetic resonance method has been applied to investigate the magnetic properties of complexes containing elements of the 4*d* and 5*d* groups. It is shown that the resonance results, and such information as is available from susceptibility measurements, can be accounted for to a good approximation by assuming that there are either covalent σ-bonds or very strong electrostatic bonds in the complex (Van Vleck 1935). In the case of d^5 complexes, however, accurate measurements of the spectroscopic splitting factors show small discrepancies with this theory. Furthermore, an anomalous hyperfine structure is observed for the complex $[IrCl_6]^{2-}$, which displays lines arising not only from the Ir nucleus, but also from the surrounding Cl nuclei. These effects are ascribed to the presence of weak π-bonds, in addition to σ-bonds, in the complex (abstract following). In magnetically concentrated salts of the 5*d* group, it is found that there is strong exchange interaction between paramagnetic neighbours. A.

538.222

603. On the magnetic properties of covalent XY_6 complexes. K. W. H. Stevens. *Proc. Roy. Soc. A*, **219**, 542–55 (*Oct.* 7, 1953).

An account is given of present ideas about the electron orbits in octahedral complexes containing 4*d* and 5*d* transition elements, with particular reference to paramagnetic resonance. The complex is treated by the method of molecular orbitals with the assumption that the magnetic carriers are partly in central *d*-orbits and partly in p_π-orbits round the outer nuclei. This is shown to lead to a reduction in the orbital *g*-factor and to the possibility of observing the hyperfine structure from the outer nuclei, thus testing the initial assumptions. See also preceding abstract. A.

538.222

604. Structure of paramagnetic ilmenite. R. Chevallier. *Bull. Soc. Chim. France*, **20**, 973–4 (*Oct.*, 1953) *In French.*

The substance $TiFeO_3$ was found to obey the Curie–Weiss law with $\theta=23°$K, $C_M=3\cdot74$ between liquid N_2 and room temp. The p_B value deduced (5·49) indicates that the iron is present as Fe^{++} ions. E. P. WOHLFARTH

538.224

605. Magnetic study of amethyst. M. Leela. Letter in *Nature* [*London*] **172**, 464 (*Sept.* 5, 1953).

Reports diamagnetic susceptibility measurements on variously coloured amethyst crystals. The colouring agent is deduced to be paramagnetic (ferric ions). The magnetic anisotropy was also measured and found to be reduced (cf. quartz) by the presence of the colouring agent. E. P. WOHLFARTH

538.224 : 538.639

606. The magnetoresistance of bismuth crystals at low temperatures. P. B. Alers and R. T. Webber. *Phys. Rev.*, **91**, 1060–5 (*Sept.* 1, 1953).

Using bismuth monocrystals at 4·2°K, the magnetoresistive behaviour of the metal was investigated in fields ranging to 100 000 G. The crystals were mounted transverse to the field with the principal crystalline axis parallel to the specimen axis. It is observed that the magnetoresistance oscillates at twice the frequency of the susceptibility oscillations of the de Haas–van Alphen effect. The resistance oscillation is separated into two frequency components, one twice the other, and each component is

related to a group of electrons having a certain effective mass. The group which is thought to be primarily responsible for the de Haas–van Alphen effect produces magnetoresistance oscillations of small amplitude and of the same frequency. The other group yields larger amplitude resistance oscillations of twice this frequency. Resistance minima were found at fields of 23·2, 12·5, 8·8 and 6·5 kG when the field is perpendicular to a binary axis of the crystal. The results are discussed in terms of the theory of Davydov and Pomeranchuk (1940), and yield a degeneracy temperature of about 210°K. A.

538.224 : 538.639

607. Relation between the de Haas–van Alphen effect and the magnetoresistance in bismuth. T. G. BERLINCOURT. Letter in *Phys. Rev.*, **91**, 1277–8 (*Sept.* 1, 1953).

Reports low temperature susceptibility measurements (at 4·2°K) in fields up to $2{\cdot}5\times10^4$ oersted on a bismuth single crystal for which magnetoresistance measurements are reported in preceding abstract. Oscillations in H^{-1} occur for both phenomena and it is found that the periods are approximately the same in the two cases. E. P. WOHLFARTH

538.24

608. The Barkhausen effect in single crystals. R. S. TEBBLE AND V. L. NEWHOUSE. *Proc. Phys. Soc.* [*London*] *B*, **66**, 633–41 (*Aug.*, 1953).

Measurements have been made on the Barkhausen effect in single crystals of silicon-iron and nickel and it is shown that the results are markedly dependent on the demagnetizing factor of the specimen. The effect of a high demagnetizing factor is to reduce the magnitude of the Barkhausen effect and to produce a corresponding increase in the contribution of the reversible magnetization processes. An explanation of this effect is given. It is pointed out that the good agreement between the results of the theoretical investigation of Néel and others and the experiments of Bates on the magnetization of single crystals is probably due to the high demagnetizing factor of the specimens, which results in a close approximation to conditions of reversibility. It is suggested that the Barkhausen effect is to be associated with the movement of 180° rather than 90° boundaries. A.

538.244.2 : 621.318.423

609. The design and construction of a 1000 kW water cooled solenoid intended for experiments on nuclear alignment and adiabatic nuclear demagnetization. J. M. DANIELS. *Proc. Phys. Soc.* [*London*] *B*, **66**, 921–8 (*Nov.*, 1953).

Details are given of a solenoid which develops 50 000 Oe over a volume 3 in. dia. × 2 in. long, for a continuous input of 1000 kW. The solenoid contains no iron or other ferromagnetic material, and has a disposition of windings to produce the special field distribution required for two-stage adiabatic demagnetization. A.

538.245

610. Magnetic viscosity in platinum cobalt. A. W. SIMPSON AND R. H. TREDGOLD. Note in *Proc. Phys. Soc.* [*London*] *B*, **66**, 805–7 (*Sept.*, 1953).

Reports results of experiments on an alloy containing equal atomic concentrations of Pt and Co. The results are similar to those obtained earlier on Alnico II [Abstr. 384 (1950)]. The change of the activation energy of the process δE is related to the increment in field strength δH by $\delta E = (q/kT)\delta H$; the observed value of kT/q is 8·5 and may be related to the coercive field (1400 oersted). E. P. WOHLFARTH

538.245 : 548.7

611. A proposed structure for certain domain configurations on a single crystal of nickel. G. W. WILSON. Note in *Proc. Phys. Soc.* [*London*] *A*, **66**, 840–1 (*Sept.*, 1953).

The proposed structure is based on the theoretical scheme due to Néel [*J. Phys. Radium*, **5**, 241 (1944)] and gives good agreement with observed powder patterns on a nickel crystal [Abstr. 8044 (1951)]. E. P. WOHLFARTH

ELECTROMAGNETISM . ELECTRODYNAMICS 538.3/.5

538.3 : 621.3

612. The forty-fourth Kelvin lecture. "The dilemma of Lord Kelvin." P. I. DEE. *Proc. Instn Elect. Engrs*, *I*, **100**, 301–4 (*Nov.*, 1953).

538.3 : 621.3.013

613. Calculation of magnetic fields (Technical electrodynamics. Vol. I). [Berechnung magnetischer Felder (Technische Elektrodynamik. Band I)]. F. OLLENDORFF. *Vienna: Springer-Verlag* (1952) x + 432 *pp. In German.*

538.31 : 621.3.013 : 621.3.011

614. A nonplanar circuit with a steady current in a uniform magnetic field. H. AMAR AND C. OBERMAN. *Amer. J. Phys.*, **21**, 518–19 (*Oct.*, 1953).

It is shown that the forces on a non-planar circuit are the same as those on an equivalent plane circuit uniquely determined. A.

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.566

615. Theory of the diffraction of electromagnetic waves at a completely conducting circular disk and associated problems. J. MEIXNER. *Ann. Phys.* [*Leipzig*] **12**, *No.* 4–6, 227–36 (1953) *In German.*

An extension of previous work on plane waves [Abstr. 7378 (1950)]. In the present work the waves originate from dipoles of arbitrary location and direction. For the special case of a solenoidal field, diffraction at an ellipsoid of revolution is also treated. Numerical evaluation is facilitated by the use of spheroidal functions. S. C. DUNN

538.566

616. Diffraction of electromagnetic waves by an aperture in a large screen. G. BEKEFI. *J. appl. Phys.*, **24**, 1123–30 (*Sept.*, 1953).

It has been shown that an approximate solution for the diffraction of an electromagnetic wave by an aperture in a plane conducting screen can be obtained from a single component of the Hertz vector and that

the results can be applied to calculating the field of apertures which are sufficiently large as compared to the wavelength of the incident radiation. The solution rests upon an evaluation of an inhomogeneous scalar boundary-value problem. An infinitesimal wavelength approximation leads to a simple Kirchhoff-like formula which is found to be identical to that obtained by Neugebauer who derived it from geometrical optics as first approximation. The special case of diffraction by a circular aperture is treated in detail and experimental measurements by which the theory was checked are cited. A.

538.566

617. Solution of electromagnetic scattering problems as power series in the ratio (dimension of scatterer)/wavelength. A. F. STEVENSON. *J. appl. Phys.*, **24**, 1134–42 (*Sept.*, 1953).

It is shown that the scattered field and the field inside the body can be expressed formally as power series in the above ratio, the calculation of successive terms in the series requiring the solution of standard problems in potential theory, together with the evaluation of certain potential integrals, so that the process can be carried as far as desired if Laplace's equation can be solved in the co-ordinate system appropriate for the body. The convergence of the series for the scattered field becomes progressively worse as we recede from the body, but an alternative expression for the field, also proceeding in powers of the same parameter, gives a representation which is valid everywhere except in the immediate neighbourhood of the body (in particular, in the wave zone) and which does not suffer from this defect. The case of a perfect conductor, or diffraction through a hole in a perfectly conducting screen, can be treated as particular cases of the general theory. The paper can be regarded as an extension of Rayleigh's work, which confines itself to the first terms in the series. A.

538.566

618. Electromagnetic scattering by an ellipsoid in the third approximation. A. F. STEVENSON. *J. appl. Phys.*, **24**, 1143–51 (*Sept.*, 1953).

The method of the preceding abstract is here applied to the ellipsoid, the first three terms in the series being obtained. The second term in the series for the wave zone field (that proportional to k^3) vanishes, and the same is true of any body possessing a centre of symmetry. Thus the terms in k^2, k^4 in the wave zone field are here obtained. The direction and polarization of the incident wave, and the electromagnetic constants of the ellipsoid, are arbitrary. The final results are expressed in terms of certain elliptic integrals which are functions of the three principal axes of the ellipsoid. These integrals can all be expressed simply in terms of just two such integrals; they become elementary integrals in the case of a spheroid. Various special cases are considered, including that of a perfectly conducting elliptical disk and the complementary problem of diffraction through an elliptical hole in a perfectly conducting screen. A.

538.566

619. The vector wave function solution of the diffraction of electromagnetic waves by circular disks and apertures. I. Oblate spheroidal vector wave functions. C. FLAMMER. *J. appl. Phys.*, **24**, 1218–23 (*Sept.*, 1953).

Rigorous solutions are presented of the problems of diffraction of plane electromagnetic waves by an infinitely thin, perfectly conducting, circular disk and by a circular aperture in a plane conducting screen. The analysis utilizes oblate spheroidal vector wave functions. These are defined and the expansions of plane-polarized waves in terms of them are obtained. A.

538.566

620. The vector wave function solution of the diffraction of electromagnetic waves by circular disks and apertures. II. The diffraction problems. C. FLAMMER. *J. appl. Phys.*, **24**, 1224–31 (*Sept.*, 1953).

Rigorous solutions are presented of the problems of diffraction of plane electromagnetic waves by an infinitely thin, perfectly conducting, circular disk and by a circular aperture in a plane conducting screen. A unique solution is obtained in each case when two separate groups of the appropriate oblate spheroidal vector wave functions discussed in Pt I are combined to fulfil the condition that the ϕ component of the electric field vanish on the rims of the disk and aperture. A.

538.566 : 621.3.011

621. Diffraction of electromagnetic waves by two parallel half-planes. B. N. HARDEN. *Proc. Instn Elect. Engrs III*, **100**, 348–50 (*Nov.*, 1953).

The field of a plane wave diffracted by two parallel, thin, highly conducting sheets, equivalent to semi-infinite planes, has been measured close to the diffracting edges for various spacings between the sheets. For one spacing, experimental results are compared with values derived from the theory of Clemmow for two parallel, infinitely thin, perfectly conducting half-planes. A.

538.566 : 621.372.8

622. The diffraction of electro-magnetic waves by a semi-infinite circular wave guide. J. D. PEARSON. *Proc. Cambridge Phil. Soc.*, **49**, *Pt* 4, 659–67 (1953).

An exact solution is obtained for the diffraction of a plane harmonic electromagnetic wave incident on a semi-infinite open-ended perfectly conducting circular waveguide. A.

538.566

623. A microwave Fabry-Perot interferometer. J. O. ARTMAN. Note in *Rev. sci. Instrum.*, **24**, 873–5 (*Sept.*, 1953).

The instrument described is a form of reflection Fabry–Perot interferometer and is used in the wavelength region 5 to 40 mm. A magic T semi-reflector divides the incident beam and sends one half to an absorber, the other to the interferometer. The back face is a full reflector of aluminium, the front face, the partial reflector, consists of 1600 one-eighth inch metal balls on a polyfoam slab. Diffraction conditions are discussed. A Q value of 40 is reported. Further work on an improved partial reflector is described. S. TOLANSKY

538.566 : 621.372.8

624. The types of wave which may exist near a guiding surface. J. BROWN. *Proc. Instn Elect. Engrs III*, **100**, 363–4 (*Nov.*, 1953).

The possible types of wave which may exist near a

guiding surface are investigated and it is shown that they can be classified as guided surface waves, evanescent fields and radiation fields. The evanescent fields differ from those in a transmission line or waveguide in that all values of attenuation constant are possible. A.

538.566 : 621.392.26

625. Gratings as circuit elements of electric waves in space. G. VON TRENTINI. *Z. angew. Phys.*, **5**, *No.* 6, 221–31 (1953) *In German.*

When an electric wave in space is incident upon a wire grating the latter presents a shunt inductance to it; it is shown, for a given periodic distribution of circuit elements, how to obtain any desired shunt parameter in space. The energy transfer for several parallel wire gratings has been determined at 3 cm waves by means of an interferometer and a variety of uses on simple lattice arrangements has been indicated. Z. F. WOJNAR

538.566 : 621.392.26

626. Waveguides with "imperfect" walls. B. Z. KATSENELENBAUM. *Dokl. Akad. Nauk SSSR*, **88**, *No.* 1, 37–40 (1953) *In Russian.*

Discusses the problem of determining the velocity, attenuation, and the configuration of the field in waveguides of arbitrary cross-section, with a finite, though large, conductivity of the walls (with "non-ideal" or "imperfect" walls) particularly in the neighbourhood of the critical frequency or below it. The electric and magnetic vectors are expressed in terms of two new scalar variables ϕ and ψ, satisfying the wave equation, in Cartesian co-ordinates in the usual form, which are subsequently replaced by a system in which two co-ordinates are the normal and the tangential direction of the waveguide cross-section boundary and the third is the direction of the wave propagation. The Leontovich boundary conditions which are then introduced allow the field in the conducting wall to be simply and accurately connected with the field outside it. The calculation formulae are developed by using successive approximation in the expression of the "proper values" ("eigenwerte") in terms of a small complex parameter characterizing the material of the wall, as a power series. The highest term of this series, not vanishing at the critical frequency, is expressed in the form of closed circuit integral along the waveguide cross-section boundary. For a frequency much above the critical, the expression of the attenuation factor obtained by this method is reduced to the one usually obtained from energy consideration, on the basis of Poynting's theorem. The calculations are first made for the electric vector and then the same method, with minor modifications, is applied to the magnetic vector. N. S. JAPOLSKY

538.566 : 621.392.26 : 621.396.677

627. The theory [of the] convex wave guide lens. T. SAKURAI. *J. Phys. Soc. Japan*, **8**, 372–7 (*May–June*, 1953).

The lens is a horn formed between two large uniformly spaced metal sheets; each sheet is an anchor ring section. Narrow curved strips of uniform width form the diverging sides of the horn. The lens converts a spherical wave into a plane wave. The physical path length between corresponding input and output points is made constant. The geometry of the lens is explained and the design parameters tabulated. It is claimed that the lens and its associated feed and "reflex electromagnetic horn" have a great bandwidth (> 500 Mc/s in 4000). W. T. BLACKBAND

538.566.2

628. Propagation of electromagnetic waves in periodic layers of transparent media. C. DUFOUR AND A. HERPIN. *Rev. Opt.*, **32**, 321–48 (*June*, 1953) *In French.*

A general treatment using matrix methods of wave propagation in stratified media is given, with particular attention to the case of normal incidence upon a system of double layers of equal optical thickness. The reflection factor is completely determined, and a number of its properties for these systems are treated. The curve of the moduli of the reflection factors (the reflection coefficients) against phase difference through a single layer is shown to have two envelopes with simple equations. These equations, and the points of contact of the curve with the envelopes (corresponding closely to reflection maxima and minima) can readily be determined in practical cases. The curve of reflection phase changes similarly possesses two envelopes, and several simple relations exist between the curves for the phase changes and the moduli. D. G. AVERY

MAGNETIC EFFECTS 538.6

538.614

629. Faraday effect and birefringence. I. S. RAMASESHAN. *Proc. Indian Acad. Sci. A*, **34**, 32–40 (*July*, 1951).

Approximate formulae correlating the decrease in Faraday rotation with birefringence have been derived and these have been verified by experiments on strained glasses and plastics. It is found that for small values of birefringence, the decrease in the Faraday rotation is proportional to the square of the total birefringence. For values of the birefringence of $\lambda/30$, the decrease in the rotation is less than 1%. The Verdet constant in birefringent solids can be accurately determined provided sufficiently thin specimens are taken such that the total birefringence is small. Finally it is shown that the decrease in the Faraday rotation can itself be used as an accurate measure of the birefringence in strained solids. A.

538.632

630. The Hall effect in yttrium, lanthanum, cerium, praseodymium, neodymium, gadolinium, dysprosium, and erbium. C. J. KEVANE, S. LEGVOLD AND F. H. SPEDDING. *Phys. Rev.*, **91**, 1372–9 (*Sept.* 15, 1953).

This was studied from 300°K to 20·3°K. The ferromagnetic rare earth metals, gadolinium, dysprosium, and erbium have been studied quantitatively only above their respective Curie temperatures with gadolinium being measured to 350°C. The measurements have been made at many temperatures using an alternating current method. Yttrium, lanthanum,

gadolinium, and erbium are found to have negative Hall effects at all temperatures studied. Cerium, praseodymium, and neodymium show positive Hall effects throughout the temperature range investigated. Dysprosium metal exhibits a negative Hall effect from 300°K down to about 130°K, but below that temperature the effect is positive. This reversal is interpreted as being due to a change in the sign of the extraordinary Hall effect. The Hall coefficient of cerium is found to go through a thermal hysteresis loop in a manner similar to the electrical resistivity and other properties. Values for the ordinary Hall coefficients are obtained where necessary from the temperature variation of the Hall effect. The Hall coefficients are used to calculate for each metal the effective number of carriers, n^*, ($n^* = 1/NeR_0$), on a simple one-band model. In addition, the two-band model, assuming electron conduction in the 5*d* band and hole conduction in the 6*s* band, is used to understand the positive effect in three of the metals and to obtain curves for the number of holes in the 6*s* band as a function of the ratio of *d*-electron mobility to *s*-hole mobility. No ordered change in the magnitude and sign of the effect along the rare earth series is observed. A.

538.632 : 537.311.33

Current carrier lifetimes deduced from Hall coefficient and resistivity measurements. *See Abstr.* 462

538.632 : 537.311.33

Experimental and theoretical investigations of the isothermal and adiabatic Hall effects in selenium. *See Abstr.* 461

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11

631. The electronic structure of transition metals in alloys. B. R. COLES. Letter in *Phil. Mag.*, **44**, 915–16 (*Aug.*, 1953).

The dependence of the stable electronic configuration of a transition metal atom on the electron concentration of the solvent metal or alloy has been demonstrated by Jones [Abstr. 8035 (1953)]. Additional evidence for this is available from work on the magnetic properties of alloys containing small amounts of the transition metals. This work is briefly summarized and interrelated. A. J. KENNEDY

539.11

632. Some relations between the modulus of rigidity and the surface and sublimation energies. G. C. KUCZYNSKI. Letter in *J. appl. Phys.*, **24**, 1250–1 (*Sept.*, 1953).

In a concise and simple manner a relation between rigidity, interatomic distance and surface energy is derived and shown to fit experiment. For simple cubic metals the rigidity is shown to equal L/Vo (where L = sublimation energy and Vo is the atomic volume) and also that the number of nearest neighbours on the surface of these metals is about 10. T. C. TOYE

539.11

633. Mobility of interstitial atoms in a face-centered metal. H. B. HUNTINGTON. *Phys. Rev.*, **91**, 1092–8 (*Sept.* 1, 1953).

Calculation of the energies of interstitial atoms in copper have been carried through in some detail using a free-electron model and approximating the repulsion of closed shells with a Born–Mayer potential. Alternate choices of constants in this potential have been employed to explore the extent of the associated uncertainty. Results show that interstitials require an activation energy of about $\frac{1}{4}$ eV or less for motion. Applications to various current experiments are pointed out. A.

539.11

634. The electronic and lattice specific heats in W, Mo, and Re. M. HOROWITZ AND J. G. DAUNT. *Phys. Rev.*, **91**, 1099–106 (*Sept.* 1, 1953).

Calorimetric measurements were made in the temperature range 1°K to 77°K on W, Mo, and Re. At the lowest temperatures for W and Mo the specific heat could be resolved into a lattice T^3 function together with an electric term, γT. It was found that at the lowest temperatures, (*a*) for W, $\theta = 250$°K to 380°K and $\gamma = (1{\cdot}8 \pm 0{\cdot}7)\times10^{-4}$ cal/mole-deg^2, (*b*) for Mo, $\theta = 445$°K and $\gamma = (5{\cdot}1 \pm 0{\cdot}4)\times10^{-4}$ cal/mole-deg^2. These new measurements on tungsten indicate the need for revising previously quoted data. The measured lattice specific heat of tungsten agreed approximately with the theoretical computations made by Fine (1939). The measured lattice specific heat of molybdenum varied with temperature in the manner predicted by Fine for the body-centred cubic lattice of tungsten. The measured electronic specific heat of tungsten was in moderate agreement with the theoretical computation of Manning and Chodorow (1939), and the measured electronic specific heats of W and Mo were considerably less than those of most other transition elements except Cr, a result which may be approximately explained by assuming a *d*-band similar to that calculated by Slater (1936). The question of the *d*-band shape is discussed in detail in the light of recent experimental results. Pure rhenium powder has been measured in the temperature range 68°K to 77°K. At these temperatures the Debye temperature, θ, was found equal to 262°K. A.

539.11

635. The energy band structure of a linear metal. E. P. WOHLFARTH. *Proc. Phys. Soc.* [*London*] *A*, **66**, 889–93 (*Oct.*, 1953).

A tight binding calculation of the one-electron energy as a function of wave number is described for a linear chain of hydrogen atoms in the ground state. The calculation is accurate to the order of exp $(-2a)$, where a is the interatomic distance (in atomic units), all non-orthogonality and energy integrals of this order of magnitude being included in the energy expression. A closed expression for the band width is derived and compared with expressions correspond-

ing in their approximations to those usually made in tight binding calculations for actual metals. A.

539.11

636. The surface free energy of a metal. I. Normal state. R. STRATTON. *Phil. Mag.*, **44**, 1236–46 (*Nov.*, 1953).

The surface energy of a metal in the normal state is calculated using the model of a free electron gas in a finite potential well. A careful distinction is drawn between the "lattice surface" (i.e. the surface which just contains all the cells of the lattice) and the surface of the well. A previous calculation [Huntington, Abstr. 5628 (1951)] for the terms due to electronic kinetic energy is repeated in a modified form; it is shown how sums over wave number space can be replaced by integrations if a surface dependent density is used. Further a calculation by Huang and Wyllie [Abstr. 2202 (1949)] is criticized in relation to the present results. An estimate of the electrostatic energy of the double layer at the surface is given. A.

539.11 : 530.162

A new approximation method for order-disorder problems. *See Abstr.* 103

539.11 : 537.312.62

637. The surface free energy of a metal. II. Superconducting state. R. STRATTON. *Phil. Mag.*, **44**, 1247–58 (*Nov.*, 1953).

The matrix elements of the electron-lattice interaction, for a plate of finite thickness, are calculated using Bethe's (1933) method. These are then used to calculate the energy of the superconducting state as described by Fröhlich [Abstr. 325 (1951)]. Previous calculations are extended by including terms proportional to the surface area. The technique of replacing sums by integrals with surface dependent densities has been used throughout. A.

539.11 : 538.114

638. Use of non-orthogonal wave functions in the treatment of solids, with applications to ferromagnetism. W. J. CARR, JR. *Phys. Rev.*, **92**, 28–35 (*Oct.* 1, 1953).

It is proved by a rearrangement of Löwdin's solution to the many-body problem that a vector model type energy expression is valid for a solid provided (in the simplest case of one electron per atom) the number of nearest neighbours times the overlap integral between them is small compared with unity. The approximation is also carried to include third-order permutation terms, and the spin coupling via closed shells these "triple exchange" terms can produce is discussed. General expressions are given for the exchange integrals to be used in a vector model solution. These under the proper conditions reduce to the conventional integrals except for a slight modification, which helps to make the integrals negative. A.

MOLECULAR STRUCTURE 539.13

539.13

639. On the inelastic collision between molecules. II. Rotational transition of H_2-molecule in the collision with another H_2-molecule. K. TAKAYANAGI. *Progr. theor. Phys.*, **8**, 497–508 (*Nov.*, 1952).

For Pt I, see Abstr. 3029 (1953). Rotational transition of an H_2 molecule in collision with another H_2 molecule is considered. The general derivation of the cross-section and an example of numerical calculation by a simplified method of approximation are presented. The result is compared with an experimental value of the transition rate in H_2 gas obtained from the anomalous u.s. dispersion. The agreement of the calculated and the experimental rates is found to be within a factor of 2, which is better than expected at the accuracy of approximation employed and with the present knowledge of intermolecular forces. A.

539.13

640. Note on thermal relaxation of CO_2 in presence of H_2O and D_2O molecules. D. SETTE AND J. C. HUBBARD. *J. Acoust. Soc. Amer.*, **25**, 994–7 (*Sept.*, 1953).

The large effect of water vapour on the thermal relaxation of carbon dioxide has not yet been satisfactorily explained. In order to have more information on the characteristics of the phenomena involved the authors have tried to compare the effects produced by H_2O and D_2O molecules on the relaxation of carbon dioxide by determining the changes in the dispersion curve. Commercial CO_2 was used. The shape of the dispersion curve shows a departure from the single relaxation time theoretical curve, which increases with the H_2O and D_2O content. If this result is confirmed by others, it would indicate that these impurities strongly affect the mechanism of energy transfer among CO_2 molecules. The objection, however, can be made that during the experiments the water absorbed on the walls of the interferometric system has been assumed not to vary. In any case the comparison between the effects of H_2O and D_2O can be made. The values 1·86 and 2·50 were found for the respective ratios of the transition probabilities in the collision H_2O–CO_2 and D_2O–CO_2, the two values being determined from two different sets of mixtures. An approximate theoretical calculation of the ratio of the transition probabilities considering only the mass change of the added impurity, gives a value 1·25. The same ratio would instead be less than unity if the important process were the energy exchange between rotation of H_2O or D_2O molecules and vibration of CO_2 molecules. The latter mechanism does not seem therefore to be responsible for the large decrease of relaxation time when water vapour is added to carbon dioxide. A.

539.13

641. Interactions of randomly disordered molecules. M. ATOJI AND W. N. LIPSCOMB. *J. chem. Phys.*, **21**, 1480–6 (*Sept.*, 1953).

Some generalizations of previous theoretical expressions for the mean potential energy of interaction between two randomly disordered molecules have been derived and have been generalized to interactions in a molecular lattice. Values of the heats of vaporization of some tetrahedral molecules and halogens have been calculated, with results in reasonable agreement with experimental values. Application of the theory to the heat of sublimation of a disordered solid, hexachloroethane, is also discussed. A.

539.132

642. Dissociation energy of Hg_2. J. G. WINANS AND M. P. HEITZ. *Z. Phys.*, **135**, *No.* 4, 406–7 (1953) *In German.*

In previous work [Abstr. 352 (1953)] the dissociation energy of Hg_2 was calculated ($D = 0{\cdot}142$ eV), and considered as the difference between the lowest vibrational state of the molecule and the maximum of the potential curve. As this was calculated from an equation based on equilibrium conditions, it is more correct to consider this value as the difference between the lowest state and the asymptotic value. For comparison with experiment a correction is made to account for the increase of atomic distance because of rotation. ($D = 0{\cdot}146$ eV.) Relations are given for this difference in energy and for the mean thermal rotation energy. A. J. TAYLOR

539.132

643. Tables of integrals useful for the calculations of molecular energies. III. M. KOTANI, E. ISHIGURO, K. HIJIKATA, T. NAKAMURA AND A. AMEMIYA. *J. Phys. Soc. Japan*, **8**, 463–76 (*July–Aug.*, 1953).

For previous parts see *Proc. Phys.-Math. Soc. Japan*, **20**, *Extra No.* 1 (1938); **22**, *Extra No.* 1 (1940). Coulomb, exchange, ionic integrals and one-electron integrals which involve $2s$ and $2p$ orbitals have been calculated for homopolar diatomic molecules. Slater type orbitals have been used, with equal values for the exponent δ. Two-centre integrals are tabulated as functions of $\alpha = \delta R$ (R: internuclear distance). This completes the project of tabulation. A.

539.132

644. Carbon-carbon bond dissociation energies in the cycloalkanes. F. H. SEUBOLD, JR. Letter in *J. chem. Phys.*, **21**, 1616–17 (*Sept.*, 1953).

The dissociation energy is calculated from published heats of formation on cycloalkanes together with the calculated heat of formation of the bi-radical formed by fission of the C–C bond. The latter is determined as the sum of the heat of formation of the corresponding alkane, the energy required to transform to the coiled configuration of the cycloalkane, the dissociation energy of the terminal C–H bonds, and the association energy of hydrogen, all of which can be obtained from accurate published data. The D (C–C) from C_3 (50 kcal/mole) to C_9 (84) with an estimated error of 2 kcal/mole are tabulated with associated data. H. H. GREENWOOD

539.132

645. The interaction with molecular rotation of the nuclear electric quadrupole moments of two nuclei having spins 3/2. G. W. ROBINSON AND C. D. CORNWELL. *J. chem. Phys.*, **21**, 1436–42 (*Sept.*, 1953).

The theory of nuclear electric quadrupole effects in molecules is applied to the particular case of a molecule containing two nuclei each having spin 3/2. The matrix elements of the first-order Hamiltonian of interaction between the nuclear electric quadrupole moments and the molecular rotational angular momentum are determined in the $I_1I_2IJFM_F$ representation. In one particular case the secular equations may be solved explicitly for the energy levels in terms of J, and the general solutions as well as their numerical values for $J \leqslant 12$ are given. For the other cases, higher-order secular equations must be solved, and to facilitate this, coefficients in the expanded secular determinants have been computed. The method for obtaining relative line strengths for transitions is described, and numerical values of these are given for some transitions. Applications to the analysis of rotational spectra are also discussed. A.

539.132

646. Experimental evidence of restricted rotation in CH_3–C≡C–CF_3. B. BAK, L. HANSEN AND J. RASTRUP-ANDERSEN. Letter in *J. chem. Phys.*, **21**, 1612–13 (*Sept.*, 1953).

Heat capacity measurements show that CH_3–C≡C–CH_3 has a zero or a very low rotation barrier. As it has no dipole moment it is not suitable for microwave studies, so CH_3–C≡C–CF_3 was investigated, which has no spin hyperfine structure complications. Its synthesis is described. The microwave spectrum was intermediate between that of a molecule with fairly high barrier which would be similar to that of CH_3CF_3, and that of one with no barrier which would have shown a spectrum identical to that of a rigid rotator. Two groups of lines were found, which must represent the $J = 7 \rightarrow 8$ and $J = 8 \rightarrow 9$ transitions, which are complicated by restricted rotation. Accordingly there must indeed be a rotation barrier which is less than 1200 cal/mole, but the actual height will be difficult to establish with the use of ordinary Stark technique, as some quadratic Stark components coincide with unperturbed lines. A. J. TAYLOR

539.132

647. Hindered rotation involving two asymmetric groups. D. G. BURKHARD. *J. chem. Phys.*, **21**, 1541–9 (*Sept.*, 1953).

The wave equation is derived for two partially asymmetric tops rotating about a common axis and subject to an arbitrary hindering potential. Matrix elements of the Hamiltonian are evaluated using the hindered-rotation wave functions derived by Koehler and Dennison on the basis of a simplified model. Evaluation of matrix elements involving the Eulerian polar angle is carried out by obtaining and making use of the factorizations of the symmetric-top wave equation. A.

539.132 : 532.7

648. Hindered molecular rotation in liquid crystals. R. D. SPENCE, H. S. GUTOWSKY AND C. H. HOLM. Letter in *J. chem. Phys.*, **21**, 1891 (*Oct.*, 1953).

The detailed shape of the proton magnetic resonance curve of para-azoxyanisole as a function of temperature is explained in terms of the internal and molecular rotations possible for the various phases. D. H. WHIFFEN

539.132 : 530.145

649. The excitation of molecular rotations and vibrations in inelastic scattering processes. E. H. KERNER. *Phys. Rev.*, **91**, 1174–81 (*Sept.* 1, 1953).

A discussion is first given of the collisions of composite systems in general, where it is shown how the scattering amplitude may be written as a superposition of little amplitudes for the scattering of each

particle in one system by each particle in the other. This is followed by the calculation of scattering cross-sections for single charges by nitrogen molecules with excitation of rotational and vibrational states of motion; the collision of molecules with molecules, including the case that they are identical, is also discussed and applied to N_2–N_2 scattering. The smallness of internal rotational and vibrational velocities is exploited in the use of the Born approximation. Detailed numerical results are given. A.

539.132 : 535.338.42

The vibrational and rotational constants of the NO_2 molecule. *See Abstr.* 257

539.132 : 535.338.42

Molecular structure of allene. *See Abstr.* 265

539.132 : 535.343

Vibrational spectra of fluorinated aromatics. *See Abstr.* 266–9

539.132 : 535.343–14

Theory of the rotational spectra of allene-type molecules. *See Abstr.* 264

539.132 : 535.343–15 : 535.375.5

650. The vibrational spectra and structure of nitrogen tetrasulfide. E. R. Lippincott and M. C. Tobin. *J. chem. Phys.*, **21**, 1559–65 (*Sept.*, 1953).

The infrared and Raman spectra of nitrogen tetrasulphide (N_4S_4) are presented along with the infrared spectrum of nitrogen hydrogen sulphide ($N_4S_4H_4$). These data have been considered in terms of the several proposed structures for nitrogen tetrasulphide and have been found to be consistent with a cage structure of D_{2d} symmetry. With the aid of a normal co-ordinate analysis of the non-degenerate symmetry species, a complete assignment of frequencies to their normal modes of vibration has been made for nitrogen tetrasulphide. A tentative assignment of frequencies is also given for nitrogen hydrogen sulphide. A.

539.132

651. Electronic states of F_2- and O_2-molecules. W. Watari. *Progr. theor. Phys.*, **8**, 524–30 (*Nov.*, 1952).

Electronic states of the F_2 molecule are first discussed on the basis of an assumption that the component F atom is an ideal system which consists of five $2p$ electrons and a nucleus of charge $5e$ (perfect screening by $1s$ and $2s$ electrons). The result of the calculation is that the ground state is $^1\Sigma_g^+$ and its dissociation energy and the corresponding equilibrium nuclear distance are 26·0 eV and $0{\cdot}840 \times 10^{-8}$ cm, respectively. Experiment shows that the ground state is $^1\Sigma_g^+$, the dissociation energy is smaller than 2·75 eV, and the corresponding equilibrium nuclear distance is $1{\cdot}435 \times 10^{-8}$ cm. The disagreement of the present result with experiment may be due to the neglect of the effect of s electrons. In the case of the O_2 molecule the electron configuration of the O atom is assumed to be $1s^2 2s^2 2p_\sigma 2p_\pi^3$, and $1s^2 2s^2 2p_\sigma$ "the molecular core." Thus the interaction between two ideal atoms, each of which consists of three $2p_\pi$ electrons and a nucleus, is discussed. The calculated result is found to account for experiment. A.

539.132

652. Calculation of heteronuclear molecular integrals. T. Murai and G. Araki. *Progr. theor. Phys.*, **8**, 615–38 (*Dec.*, 1952).

Reduction formulae and numerical tables of heteronuclear molecular integrals and auxiliary integrals are given for several values of parameters. A.

539.132

653. Molecular structure and absorption spectra of carotenoids. G. Araki and T. Murai. *Progr. theor. Phys.*, **8**, 639–54 (*Dec.*, 1952).

An assemblage of π-electrons in the chain of carotenoid molecules is discussed, according to Tomonaga's method, on the basis of an assumption that the electrons are kept in a pipe whose length is equal to the chain length of conjugated double bonds. The spin degrees of freedom of electrons are taken into account though Tomonaga disregarded them. The one-dimensional potential of two-electron forces is assumed to be given by an average of the Coulomb repulsive potential over a section of the pipe. The calculated values of absorption maxima are in good agreement with experiment for carotenoids. The adequacy of the method is discussed. A.

539.132

654. Contribution to the knowledge of the π electron states of the carbonyl group. E. Scrocco and O. Salvetti. *Ricerca sci.*, **23**, 1410–22 (*Aug.*, 1953) *In Italian.*

The π electron states are studied here without using semi-empiric parameters. The basic atomic functions are of Slater's type with effective charges derived directly from the atomic ionization potentials. Results are given for the energies calculated (at different values of the internuclear distance) for electric moment, and ionization potential. A comparison is made with similar results, obtained using the Zener and Slater's values for the effective charges. A.

539.132

655. $\sigma\pi$ interaction in benzene. K. Nisa. *J. Phys. Soc. Japan*, **8**, 630–42 (*Sept.–Oct.*, 1953).

The influence of σ electrons, through exchange interaction with π electrons, on the lower excited electronic levels of benzene was estimated by assuming the approximation of electron pair bonds (e.p.b.) for σ electrons. The result shows an enhancement of excitation energy of every excited level by an amount of a few electron volts, and the shift of $^1E_{2g}$ level is the least in favour of Craig's assignment of this level to the observed 6·2 eV band. In this approximate treatment by the method of e.p.b.: (1) a choice of values of one-centre atomic integrals between semi-empirical and computed values affects the result a little; (2) an error resulting from neglect of two-centre molecular integrals over non-adjacent neighbour AO's is found to be negligible; (3) a contribution from three- and four-centre integrals to the excitation energy is presumably smaller than 0·1 eV except from a few of them; (4) neglect of potentials from H atoms and of overlappings between AO's of σ electrons are found to be not so serious; (5) inclusion of configuration interaction of π electrons would not affect the result much. As a different approach to

the problem, non-localized MO's are assumed for σ electrons, tentatively, and the $\sigma\pi$ interaction computed. The result is similar to that given by the e.p.b. approximation. A.

539.132

656. Electronic energy levels of molecular oxygen. A. MECKLER. *J. chem. Phys.*, **21**, 1750–62 (*Oct.*, 1953).

A configuration interaction study of the lower-lying electronic energy levels of molecular oxygen is made. With the 1*s* and 2*s* shells kept filled, the remaining eight electrons are distributed among the twelve spin-orbitals arising from the 2*p* levels on each atom. The atomic functions are represented as Gaussians, which are poor atomic functions but facile integrands in many-centre integrals. The molecular orbitals are formed as symmetrical linear combinations of the atomic orbitals, simply for convenience. Inclusion of all configurations implies complete equivalence of all possible constructions of linear combinations. Out of the 495 configurations (many-electron determinants) a group of nine states of $^3\Sigma_g^-$ character is set up and twelve of $^1\Sigma_g^+$ character. The interaction matrix of each block is computed and diagonalized (by electronic computer). The results for the ground state, which is a triplet, are very good. The binding energy is off by 2%, the internuclear distance is off by 1%, the fundamental nuclear vibration frequency is off by 4%. The lowest singlet state is not given as accurately. The energies and wave functions for the lowest triplet and singlet are calculated and compared for various values of internuclear separation. Discussion is made of the validity of single configuration theory, from both the Heitler–London and Hund–Mulliken points of view. A.

539.132

657. Proton relaxation phenomena in complex ion formation. J. R. ZIMMERMAN. Letter in *J. chem. Phys.*, **21**, 1605 (*Sept.*, 1953).

In solutions of V^{4+} a slight increase of the relaxation time T_1 and a marked decrease of T_2, for the proton magnetic resonance, are observed as oxalic acid is added to form complexes with the V^{4+}. D. H. WHIFFEN

539.132

658. Nuclear magnetic resonance splittings in weak fields. W. E. QUINN AND R. M. BROWN. Letter in *J. chem. Phys.*, **21**, 1605–6 (*Sept.*, 1953).

The splitting in nuclear magnetic resonance shown by Gutowsky and Hoffman [Abstr. 433 (1952)] at 6385 gauss was observed unchanged at lower fields, 150–400 gauss in HPF_6, $HPO(OH)_2$, etc. The doublet F resonance structure in $F_2PO(OH)$ appeared at 550 gauss with width 0·240 gauss, but the peaks coalesced gradually at lower fields to give one line at 200 gauss. D. H. WHIFFEN

539.132

659. Free-electron wave functions for conjugated molecules. C. A. COULSON. Note in *Proc. Phys. Soc.* [*London*] *A*, **66**, 652–5 (*July*, 1953).

It is shown that the similarity between the FE and LCAO MO wave functions for a conjugated polyene chain implies that the electron is free to move a further distance beyond each end of the chain. The similarity is established in a more general way by relating analytically the typical one of a set of MO secular equations for a polyene chain to the Schrödinger wave equation for a free electron moving along the chain. The conditions under which this can be done apply to the lower levels, but begin to break down for excited levels. The analysis suggests that for branched chains and condensed systems where the number of tertiary atoms is large, the best FE model is that of a two-dimensional box. H. H. GREENWOOD

539.132

660. Studies in molecular orbital theory of valence. II. The transition state in Walden inversion type reactions. H. H. JAFFÉ. Letter in *J. chem. Phys.*, **21**, 1618 (*Sept.*, 1953).

For previous part see Abstr. 1818 (1953). The transition state for the reaction $ACH_3 + A^* \rightarrow A + CH_3A^*$ is assumed to consist of a planar CH_3 group with A and A* lying symmetrically on either side of the central C atom. Appropriate molecular orbitals suggest that each CA bond in the transition state is a one-half bond of order $(2)^{-\frac{1}{2}}$. It should therefore be possible to deduce the bond lengths and energies from published curves, and hence determine the energy of the transition state. A correction for the change in hybridization in the C–H bonding orbitals and various other refinements are considered. H. H. GREENWOOD

539.132

661. The calculation of vibrational transition probabilities of diatomic molecules. R. W. NICHOLLS, W. R. JARMAIN AND P. A. FRASER. Note in *Canad. J. Phys.*, **31**, 1019–21 (*Sept.*, 1953).

The amplitude integral $(v'R_e v'')$ may be reduced by assuming an average value for R_e the electronic transition integral. Relative approximate vibrational transition probabilities for the vibrational states v' and v'' are then given by $(v'v'')^2$, which may be evaluated using vibrational wavefunctions for a Morse potential. For higher quantum numbers the Laguerre polynomials exhibit much cancellation and are difficult to evaluate. A simplification is introduced by replacing the exponents α_1 and α_2 of the Morse potentials by a mean $\alpha = \frac{1}{2}(\alpha_1 + \alpha_2)$. The change represents a small distortion of the Morse potential, but as this itself is only approximate, the new potentials and wave functions may be equally good. The extent of the numerical work involved in this method is discussed and results quoted for the First Positive band system of N_2 agree well with those obtained by the old method. H. H. GREENWOOD

539.132

662. Free-electron network model for conjugated systems. I. Theory. K. RUEDENBERG AND C. W. SCHERR. *J. chem. Phys.*, **21**, 1565–81 (*Sept.*, 1953).

The free-electron model for conjugated systems is consistently developed as the limiting case of a three-dimensional quantum mechanical treatment of the π electrons in such systems. Joint conditions (for branching points) and boundary conditions (for free end points) are derived and the Hermiticity of the Hamiltonian is shown. A matrix formulation of the theory is established which makes the application to

large systems feasible, and at the same time leads to a close analogy with the LCAO model (LCAO MO treatment considering only nearest neighbour interactions). Quantities analogous to the quantities q (the charge in an atomic orbital) and p (the bond order) are defined, and special attention is given to alternant conjugated systems for which a population theorem, analogous to the one in LCAO theory, is valid. A.

539.132

663. Free-electron network model for conjugated systems. II. Numerical calculations. C. W. Scherr. *J. chem. Phys.*, **21**, 1582–96 (*Sept.*, 1953).

Numerical calculations are carried out on a large number of aromatic and polyene type conjugated molecules by the methods of Pt I. These calculations include all energy levels, the wavelengths of the first four electronic transitions, the complete π-electron wave functions, the bond densities and bond orders, free valence and reactivities, and dipole moments. A method of estimation of bond lengths with a root mean square error of 0·016 Å is presented. Wherever possible comparisons are made with experiment and with the results of the LCAO molecular orbital theory in the approximation developed by Coulson and Longuet-Higgins. The results in general are at least as good as those of the LCAO calculations. A.

539.132

664. Free-electron network model for conjugated systems. III. A demonstration model showing bond order and "free valence" in conjugated hydrocarbons. J. R. Platt. *J. chem. Phys.*, **21**, 1597–1600 (*Sept.*, 1953).

A mechanical model of a conjugated hydrocarbon has been constructed, based on the free-electron density theorems of Ruedenberg and Scherr. Stiff steel music wires strung on dowels above a baseboard follow the carbon skeleton. When the height of the wire above the board at each atomic position is fixed to constant theoretical values, and when simple boundary conditions are met at branch points and terminal atoms, then the height in the centres of bonds is a direct measure of electron density and bond order and "free valence." The measured heights may be used to predict bond lengths and positions of substitution, even for large or unsymmetrical molecules which are hard to handle theoretically. The model should be especially useful for demonstrations and for giving students a feeling for electronic behaviour in conjugated systems. A.

539.132

665. Contribution to the variational calculation of molecular polarizabilities. J. Barriol and J. Régnier. *C.R. Acad. Sci.* [*Paris*] **237**, 307–8 (*July* 27, 1953) *In French.*

An operational form allows the mean energy of a perturbed state to be evaluated by comparatively simple integrations. This has proved useful for the polarizabilities of π-electrons in C_2H_4. J. JACOBS

539.132

666. Determination of rates of change of polarizability from Raman and Rayleigh intensities. E. J. Stansbury, M. F. Crawford and H. L. Welsh. *Canad. J. Phys.*, **31**, 954–61 (*Sept.*, 1953).

Mean values of the rate of change of polarizability with respect to internuclear distance were determined for several molecules from the ratio of Raman and Rayleigh intensities in the gas. The values obtained are: hydrogen, $1{\cdot}2\times10^{-16}$ cm^2; deuterium, 1·1; hydrogen chloride, 1·0; hydrogen bromide, 1·2; nitrogen, 1·6; oxygen, 1·4; carbon dioxide (ν_1 vibration), 4·2; methane (ν_1 vibration), 4·1. It is noteworthy that the values for the partially ionic molecules, hydrogen chloride and hydrogen bromide, are nearly the same as for hydrogen and deuterium. A.

539.133

667. Dipole moments of some organic selenium compounds. L. Chierici, H. Lumbroso and R. Passerini. *C.R. Acad. Sci.* [*Paris*] **237**, 611–13 (*Sept.* 21, 1953) *In French.*

The dipole moments of $C_6H_5SeCH_3$ and $C_6H_5SeC_2H_5$ and related compounds were measured. The π electron parts were estimated by comparison with $(C_2H_5)_2Se$ and, for geometrical factors, with p-methyl derivatives [see Abstr. 7022 (1953)]. The inductive part of the π moment, negative in sign, and the delocalization part (positive), due to hyperconjugation between the lone pair of the substituent and the conjugated system, were estimated by comparison with corresponding O and S compounds. For $C_6H_5XCH_3$ the π moments decrease in the order $O > S > Se$, as do the electronegativities of the substituents, and hence the inductive effect. The delocalization effect decreases in the same order, and is small for Se. J. HAWGOOD

539.133

668. Microwave spectra and molecular structures of $HSiCl_3$, CH_3SiCl_3, and $(CH_3)_3SiCl$. R. C. Mockler, J. H. Bailey and W. Gordy. *J. chem. Phys.*, **21**, 1710–13 (*Oct.*, 1953).

From measurements of pure rotational transitions in the microwave region, the following molecular constants have been obtained. The B_0 values are in Mc/s, $2472{\cdot}45 \pm 0{\cdot}04$ for $HSi^{28}Cl^{35}_3$; $2346{\cdot}07 \pm 0{\cdot}04$ for $HSi^{28}Cl^{37}_3$; $1769{\cdot}84 \pm 0{\cdot}03$ for $C^{12}H_3SI^{28}Cl^{35}_3$; $1699{\cdot}79 \pm 0{\cdot}03$ for $C^{12}H_3Si^{28}Cl^{37}_3$; $2197{\cdot}44 \pm 0{\cdot}04$ for $(C^{12}H_3)_3Si^{28}Cl^{35}$; and $2147{\cdot}88 \pm 0{\cdot}03$ for $(C^{12}H_3)_3Si^{28}Cl^{37}$. With $d_{SiH} = 1{\cdot}47$ Å (assumed), it is found for $SiHCl_3$ that $d_{SiCl} = 2{\cdot}021$ Å and $\angle ClSiCl = 109° 22'$. With the CH_3 configuration assumed as in methane and $\angle ClSiCl$ as in $SiHCl_3$ it is found for CH_3SiCl_3 that $d_{SiC} = 1{\cdot}876$ Å and $d_{SiCl} = 1{\cdot}021$ Å. With all bond angles assumed to be tetrahedral and the CH distance to be that in methane, it is found for $(CH_3)_3SiCl$ that $d_{SiC} = 1{\cdot}87$ Å and $d_{SiCl} = 2{\cdot}03$ Å. A.

539.133

669. Microwave spectrum and molecular structure of trichloro germane. P. Venkateswarlu, R. C. Mockler and W. Gordy. *J. chem. Phys.*, **21**, 1713–15 (*Oct.*, 1953).

From measurements of the pure rotational transitions in trichloro germane, the rotational constants B_0 (in Mc/s) for the various isotopic modifications

of the molecule were found to be: 2172·75 for $HGe^{70}Cl_3^{35}$, 2169·26 for $HGe^{72}Cl_3^{35}$, 2165·84 for $HGe^{74}Cl_3^{35}$, 2063·74 for $HGe^{70}Cl_3^{37}$, 2060·43 for $HGe^{72}Cl_3^{37}$ and 2057·20 for $HGe^{74}Cl_3^{37}$. The calculated structure from the above data for the molecule in the ground state is: $d_{GeH} = 1{\cdot}55 \pm 0{\cdot}04$ Å, $d_{GeCl} = 2{\cdot}1139 \pm 0{\cdot}0010$ Å and $\angle ClGeCl = 108° 17' \pm 12'$. Rotational lines for the molecule when it is in the two excited $GeCl_3$ deformation vibrations are also measured and the corresponding molecular structures calculated. A.

539.133

670. On the structure of oxalyl chloride. R. E. KAGARISE. Letter in *J. chem. Phys.*, **21**, 1615–16 (*Sept.*, 1953).

The observed infrared spectra of solid and liquid oxalyl chloride in the frequency range 400–3000 cm^{-1} are diagrammatically represented. The disappearance of the two strong bands at 1050 and 533 cm^{-1} upon solidification is taken to imply the presence of the *cis*-form of the molecule in the liquid state.

G. I. W. LLEWELYN

539.133

671. The geometry of ketene. W. F. ARENDALE AND W. H. FLETCHER. Letter in *J. chem. Phys.*, **21**, 1898 (*Oct.*, 1953).

The C–C and C–O internuclear distances and the H–C–H bond angle in ketene have been determined using the moments of inertia of CH_2CO and CD_2CO respectively obtained from the microwave spectra.

G. I. W. LLEWELYN

539.133

672. The volume exclusion effect in flexible chains. H. M. JAMES. *J. chem. Phys.*, **21**, 1628–36 (*Oct.*, 1953).

The volume exclusion effect in a chain of small impenetrable spheres is treated by two methods—one based on derivation of a Fokker–Planck equation by consideration of the number of ways in which a chain can be extended by adding another sphere without violating the volume exclusion condition, and the other based on the calculation of the number of excluded configurations as a function of chain extension. Both approaches lead, in the first approximation, to the same simple analytic form for the distribution of chain extensions r, and to the prediction that $\langle r^2 \rangle$ will increase faster than the number of spheres in the chain. Volume exclusion does not merely change the distribution function by a scale factor, as is assumed in the theory of Flory; there is a relatively large decrease in the probability of small extensions. The present theory is compared in detail with that of Hermans, Klamkin and Ullman [Abstr. 8988 (1952)], which is superficially similar in appearance, but fundamentally quite different in character and result. A.

539.133

673. Excluded volume in polymer chains. B. H. ZIMM, W. H. STOCKMAYER AND M. FIXMAN. *J. chem. Phys.*, **21**, 1716–23 (*Oct.*, 1953).

This discussion is concerned with the excluded volume effect in polymer chains, i.e. the mathematical problem of random flights with correlations between the flights, which is of importance in relating the mean size of a chain to its structure. A general formulation of the problem is set up and compared with the theory of Markoff processes. It is shown that although an integral equation of the Markoff form for the distribution function exists, it contains a complicated function whose exact evaluation is difficult. Since the same function occurs in the problem of the osmotic second virial coefficient, it is natural to relate the excluded volume effect to the second virial coefficient. The results of preliminary numerical calculations for the relation between the mean square radius of the chain and the second virial coefficient, in good agreement with experiment, are given. It is concluded that the volume effect is certainly not negligible for real chains, except when the second virial coefficient is zero, and that the effect increases with increasing chain length. A.

539.133 : 535.343–14

The methyl alcohol molecule and its microwave spectrum. *See Abstr.* 259

539.133 : 535.343.4–14

Structure of the phosgene molecule. *See Abstr.* 295

539.133 : 535.347–15

674. The interpretation of infrared dichroism in fibrous protein structures. R. D. B. FRASER. *J. chem. Phys.*, **21**, 1511–15 (*Sept.*, 1953).

The increasing use of infrared dichroism measurements in studying the molecular structure of fibrous proteins necessitates a critical examination of its interpretation. Relationships between transition moment direction and dichroic ratio are derived for perfectly and imperfectly oriented fibres, and the effects of reflection losses, form dichroism, and convergence are considered. Uncertainties in the assignment of the transition moment directions associated with the principal vibrations of the –CO·NH– group are discussed. A.

539.133 : 535.515

675. Dynamic double refraction and the geometrical dimensions of macromolecules in solution. E. V. FRISMAN AND V. N. TSVETKOV. *Zh. eksper. teor. Fiz.*, **23**, *No.* 6 (12) 690–702 (1952) *In Russian.*

The method of double refraction in a flow was used to study the structure of macromolecules in solution. A new universal type of dynamo-optimeter was developed, the construction of which is such that it is possible to obtain laminar flow using an internal and an external rotor. It was established experimentally that the apparatus can be used for liquids of low viscosity within a wide range of velocity gradients under conditions of laminar flow. The dynamic double refraction of solutions of polystyrene in toluene and in butanone (methyl ethyl ketone) was investigated. The coefficients of the rotational diffusion of macromolecules were determined. The radii, the degree of transparency and the degree of coagulation of macromolecules in solution were determined by a comparison of the data obtained with the values of progressive diffusion for the same solutions. The possibility was shown of determining the molecular weight of a polymer from the measurements of the orientation angle of the dynamic double refraction of its solutions. E. RABKIN

ATOMIC STRUCTURE . NUCLEUS ISOTOPES 539.15

539.152.1

676. On the charge independence of nuclear forces. S. Y. Tiwari. *Proc. Indian Acad. Sci. A*, **33**, 155–67 (*March*, 1951).

It is shown that if the electric perturbation of the meson field, responsible for the interaction between two nucleons, be taken into account, the ^1S potential between a proton-neutron pair is about 0·5% higher than the corresponding potential between a proton-proton pair in the static approximation of the symmetric meson theory for the pseudoscalar and vector mesons. A.

539.152.1

677. The *j–j* coupling shell model. M. Umezawa. *Progr. theor. Phys.*, **8**, 509–23 (*Nov.*, 1952).

The theory of *j–j* coupling in nuclei is developed. By making use of this extended theory of spin eigenfunctions in *j–j* coupling, nuclear magnetic moments are calculated, and the results are in agreement with experiment. The data on β-decay are also consistent with the present *j–j* coupling shell model. A.

539.152.1

678. On the excitation energy of a heavy nucleus described by a real Fermi gas. F. Ferrari and C. Villi. Letter in *Nuovo Cimento*, **10**, 94–7 (*Jan.*, 1953).

A generalization of the work of Euler (1937) and Watanabe (1939) is attempted by working out the interaction energy to 2nd order (Gauss 2-body potential) as function of the gas temperature T. The level density and energy are plotted up to $T = 2$ MeV. W. J. SWIATECKI

539.152.1

679. The competition between $d_{5/2}$ and $g_{7/2}$ levels in Sb, I, Cs and La; the decay of ^{135}La. A. H. Wapstra. Letter in *Physica*, **19**, 671–2 (*July*, 1953).

The relative positions of the $d_{5/2}$ and $g_{7/2}$ states in the odd-mass isotopes of Sb, I, Cs and La are exhibited graphically as a function of the neutron number, N. The results indicate strongly that Cs^{127} and Cs^{129}, and also the 19 hr La^{135}, probably have $d_{5/2}$ ground-states. A. O. STANESBY

539.152.1

680. Application of the *jj*-coupling model to moderately light nuclei. D. Kurath. *Phys. Rev.*, **91**, 1430–47 (*Sept.* 15, 1953).

An investigation based on the strong spin-orbit coupling model is made for nuclei in the $1d_{3/2}$ and $1f_{7/2}$ shells. Hartree–Fock wave functions and central forces are used in calculating ground state spins and binding energy differences. Coupling rules are found for configurations of identical nucleons and for the simplest odd-odd nuclei. Approximate wave functions are constructed for odd-A and even-even nuclei having both neutrons and protons in the $1f_{7/2}$ shell. Binding energy differences, magnetic moments and beta decay matrix elements are calculated with these functions. The result of comparing binding energy differences with experiment is interpreted as favouring strong spin-orbit coupling over weak spin-orbit coupling. A.

539.152.1

681. The energy levels of odd-odd nuclei. A. de-Shalit. *Phys. Rev.*, **91**, 1479–86 (*Sept.* 15, 1953).

A derivation of a closed formula for the energy levels of odd-odd nuclei is described, and the plausibility of the Nordheim rule is discussed. A.

539.152.1

682. The pairing effect in nuclei and isomerism. R. Katz. *Phys. Rev.*, **91**, 1487 (*Sept.* 15, 1953).

Previous workers have shown from an analysis of the energetics of α- and β-decay that the pairing energy of protons is greater than that of neutrons. It is here postulated that this effect is responsible for the absence of odd-proton isomers for $50 < Z < 82$. A.

539.152.1

683. Isotope shift anomalies and nuclear structure. L. Wilets, D. L. Hill and K. W. Ford. *Phys. Rev.*, **91**, 1488–1500 (*Sept.* 15, 1953).

When observed isotope shifts in the electronic spectra of the heavy elements have been corrected for electronic structure, the resulting shifts give new insight into nuclear structure. In comparison with the shifts predicted for constant density spherical nuclei, the reduced observed shifts are anomalous (1) in magnitude, being on the average too small by a factor 0·5, (2) in trend with neutron number, showing an oscillation in magnitude, and (3) in the staggering of shifts between even and odd isotopes. The present work shows that the anomaly in magnitude largely disappears when account is taken of the compressibility and polarizability of nuclear matter, as a result of which the nuclear radius is found to vary less rapidly with change in neutron number than is predicted by the average $A^{\frac{1}{3}}$ law. The analysis of experimental data also suggests that nuclear particle density variations are slightly greater than indicated by earlier theoretical estimates. Likewise, the oscillatory trend in isotope shifts ceases to appear anomalous when associated with the regular progression in nuclear shapes as derived from configuration theory, from the analysis of quadrupole moments and the first excited states of even-even nuclei, and from other sources. The general size of the amplitude and the nodal positions of the shift variation are consistent with expectations. Finally, the even-odd staggering in isotope shifts is reasonably to be connected with the staggering to be expected in the progression of nuclear deformations through odd and even isotopes. Thus the over-all pattern of isotope shifts appears to fit together with present ideas and to provide new specific information on nuclear structure. A.

539.152.1

684. Low-lying many-particle levels in odd mass nuclei with 21, 23, 25 or 27 protons or neutrons. R. H. Nussbaum, R. van Lieshaut and A. H. Wapstra. Letter in *Phys. Rev.*, **92**, 207 (*Oct.* 1, 1953).

The experimental evidence, part of it original, is presented and discussed in relation to configuration mixing in the shell model. P. T. MATTHEWS

539.152.1

685. The nuclear stability curve. W. G. McMillan. Letter in *Phys. Rev.*, **92**, 210 (*Oct.* 1, 1953).

A relation between A and Z is obtained for stable nuclei, based on the degenerate gas model. A comparison with the usual semi-empirical formula

[Abstr. 168 (1948)], which has the same form, gives a maximum neutron kinetic energy about 2·5× the commonly quoted value. P. T. MATTHEWS

539.152.1 : 539.155.4

686. An atomic mass study of nuclear shell structure in the region $28 \leqslant n \leqslant 50$ and $28 \leqslant Z \leqslant 40$. B. G. HOGG AND H. E. DUCKWORTH. *Canad. J. Phys.*, **31**, 942–53 (*Sept.*, 1953).

New mass spectrographic masses are reported for some of the isotopes of gallium, germanium, arsenic, and selenium. These results are combined with previously reported atomic mass data in order to study atomic mass trends in the region $28 \leqslant n \leqslant 50$ and $28 \leqslant Z \leqslant 40$. The only pronounced mass effects which occur in this region are those associated with 28 and 50 nucleons. No extra stability has been found which can be associated with the filling of the $f_{5/2}$, $p_{3/2}$, and $p_{1/2}$ subshells. A list of mass values used in this study is included. A.

539.152.1 : 539.185

687. Fast neutron cross sections and nuclear level density. D. J. HUGHES, R. C. GARTH AND J. S. LEVIN. *Phys. Rev.*, **91**, 1423–9 (*Sept.* 15, 1953).

The capture cross-sections for unmoderated fission neutrons, effective energy one MeV, are determined by the average properties of nuclear levels at excitation energies equal to neutron binding plus one MeV. The level spacings determined from measured cross-sections for 61 isotopes are discussed in connection with the statistical and shell nuclear models. Whereas the discontinuity in neutron binding energy at magic numbers accounts for most of the abnormality of the cross sections of the magic-N nuclei, the effect of shell structure is evident in level spacing even at high (5–7 MeV) excitation energy. The level spacings obtained for nonmagic-number nuclei, on the other hand, are in reasonable agreement with the statistical nuclear model, and in addition are the same for levels of widely different spin. A.

539.152.2

688. On the spin of certain odd-odd nuclei. II. Calculations and results. III. Case of potassium 40. C. MARTY, R. NATAF AND J. PRENTKI. *C.R. Acad. Sci.* [*Paris*], **237**, 31–3 (*July* 6); 137–9 (*July* 15, 1953) *In French.*

The formulae given in Pt I [Abstr. 7838 (1953)] are applied to practical cases taking the parameters occurring in the interaction between the two outer nucleons from data on the deuteron, p–n scattering and saturation of nuclear forces, and for the cases of δ-function, Yukawa and constant potential. The calculations are extended to nuclei containing one shell with a vacancy and one external nucleon. For K^{40} the spin obtained is 4, in agreement with experiment. The magnetic moment calculated with the configuration $(d_{3/2})^{-1} - f_{7/2}$ is $-1{\cdot}7$ (experimental $-1{\cdot}3$); jj-coupling is strongly indicated. L. PINCHERLE

539.152.2

689. Isotopic spin selection rules. D. H. WILKINSON. *Nature* [*London*] **172**, 576–80 (*Sept.* 26, 1953).

An elementary discussion of basic principles is followed by a brief review of experimental evidence for the selection rules. Estimates of the purity of isotopic spin states in several nuclei (Li^6 to Ne^{20}) are derived from available experimental data. J. J. WILKINS

539.152.2

690. Isotopic spin selection rules. III. Radiations from ^{14}N. A. B. CLEGG AND D. H. WILKINSON. *Phil. Mag.*, **44**, 1269–75 (*Nov.*, 1953).

For Pt II, see Abstr. 8639 (1953). It is pointed out that the 8·06 MeV $(1-)$ state of N^{14} is of $T = 1$, corresponding with the 6·10 MeV state of C^{14}. The electric dipole transition to the 2·31 $(0+)$ $T = 1$ state of N^{14} is therefore forbidden by the isotopic spin selection rules. It is shown that the strength of this forbidden electric dipole transition is less than 0·7% of that of the allowed electric dipole transition to the $(1+)$ $T = 0$ ground state of N^{14}; this implies that the contamination of the 8·06 MeV state by a state of $T = 0$ is less than 2% in intensity. A.

539.152.2

691. Polarizability of the deuteron. N. F. RAMSEY, B. J. MALENKA AND U. E. KRUSE. *Phys. Rev.*, **91**, 1162–4 (*Sept.* 1, 1953).

The theory of the polarizability of the deuteron in a uniform electric field is developed. Using the properties of the deuteron Green's function, an expression is obtained for polarizability of the deuteron which exhibits its dependence upon the spin orientation of the deuteron. This dependence arises from the inclusion of a tensor force in the neutron-proton interaction. In terms of the magnetic quantum number m, with respect to the direction of the electric field, the polarizability α is $\alpha_{SS} + (3m^2-2)\alpha_{SD} + (3m^2-2^2)\alpha_{DD}$. When Hulthén wave functions are used for the deuteron, α_{SS} is found to be approximately $0{\cdot}56 \times 10^{-39}$ cm^3 and α_{SD} $0{\cdot}027 \times 10^{-39}$ cm^3. The applicability of the theory to intramolecular interaction measurements and deuteron scattering experiments is discussed. A.

539.152.2

692. The electric scattering of the polarizable deuteron. B. J. MALENKA, U. E. KRUSE AND N. F. RAMSEY. *Phys. Rev.*, **91**, 1165–7 (*Sept.* 1, 1953).

The effect of the electric polarizability of the deuteron upon its electric scattering is discussed for cases in which $Ze^2/h\nu \gg 1$ and the classical closest distance of approach is so large that the effects of direct nuclear interaction are negligible. Under such circumstances, the chief departure from the Rutherford scattering law is due to the polarizability of the deuteron. The magnitude of the departure is calculated, and in particular, the polarizability contribution to backward scattering is estimated to be respectively about 3% and 4% for 8 MeV deuterons scattered by bismuth and uranium. A.

539.152.2

693. Nuclear magnetic moment of Cr^{53} and Sr^{87}. C. D. JEFFRIES AND P. B. SOGO. Letter in *Phys. Rev.*, **91**, 1286 (*Sept.* 1, 1953).

Nuclear induction experiments on Na_2CrO_4 with 90% Cr^{53} give $\mu(Cr^{53}) = -0{\cdot}47351 \pm 0{\cdot}00007$ n.m. if the spin is 3/2. Saturated $SrBr_2$ solutions gave $\mu(Sr^{87}) = -1{\cdot}0892 \pm 0{\cdot}00015$ n.m. if the spin is 9/2. Both values are without diamagnetic correction. D. H. WHIFFEN

539.153

694. The polarization of sodium atoms. W. B. HAWKINS AND R. H. DICKE. Letter in *Phys. Rev.*, **91**, 1008 (*Aug.* 15, 1953).

A beam of Na vapour was illuminated by circularly polarized resonance radiation and the plane-polarization ratio of the light scattered at 90° was measured as function of a magnetic field applied along the axis of the incident light. The results indicate a polarization of the Na vapour in agreement with the expected value [see Abstr. 5994 (1952)].

W. J. SWIATECKI

539.153

695. Shift of the 1^1S state of helium. S. CHANDRASEKHAR, D. ELBERT AND G. HERZBERG. *Phys. Rev.*, **91**, 1172–3 (*Sept.* 1, 1953).

It is shown that recent discussions of the problem are subject to considerable doubt, arising from the unreliability (to the required precision) of the current theoretical determinations of the energy of the ground state. The result of an improved calculation for the latter is presented; and if this is accepted as a sufficient approximation, an unexplained shift of $21 \cdot 5\ \mathrm{cm}^{-1}$ (opposite in direction to that previously suggested) would result for He. Similar unexplained shifts (but in the same direction as those suggested earlier) are also predicted for the other He-like ions. A.

539.153

696. Effective nuclear charges for atoms from self-consistent field calculations. A. J. FREEMAN. *Phys. Rev.*, **91**, 1410–17 (*Sept.* 15, 1953).

Results of calculations of $2Z_p$, the effective nuclear charge for the potential in an atom are reported for those atoms treated by self-consistent field methods. Tables of the effective nuclear charges are given for atoms in various degrees of ionization. A.

539.153

697. On the concept of an electron shell of an atom. H. BRION AND S. ODIOT. *C.R. Acad. Sci.* [*Paris*] **237**, 616–17 (*Sept.* 21, 1953) *In French.*

Two definitions are given applicable to wave functions: (i) the region enclosed between minima of the electron density curve, (ii) one based on the most probable electron configuration. Here the electrons arrange themselves on spheres, to be associated with shells, for an atom with spherical symmetry. For the case of orthohelium the configuration making the Hylleraas function give the best maximum is discussed. J. JACOBS

539.153

698. Quantum field theory of bound states. IV. Relativistic theory of the excited states of hydrogen. R. J. EDEN. *Proc. Roy. Soc. A*, **219**, 516–26 (*Oct.* 7, 1953).

For Pt III, see Abstr. 6462 (1953). When allowance is made for the instability of the excited states of hydrogen it is necessary to replace the equation of Salpeter and Bethe [Abstr. 1469 (1952)] by a set of coupled integral equations for representatives of the state vector. These representatives correspond to an electron-proton bound state and also to the electron and proton with any number of photons present. The coupled equations can be reduced to a single integral equation, which gives the electron-proton bound state as an eigenstate of a modified propagator. The modified propagator is related to the two-body propagator of Salpeter and Bethe. The difference between the first approximation to the modified propagator and the first approximation to the two-body compound propagator (Eden, 1952, 1953) can be represented by a displacement of its singularity in total energy-momentum space. This displacement gives in a relativistic form all the relevant contributions to the Lamb shift to this order; these include the contribution from low-energy transverse photons crossing over an arbitrary number of longitudinal photons; previously this term has always been deduced by physical arguments and obtained by non-relativistic methods (Bethe 1947; Salpeter 1952). The displacement of the singularity also gives decay coefficients to this order in the charge. The method can readily be extended to higher approximations. A.

539.153.4

699. Fourth-order radiative corrections to atomic energy levels. J. WENESER, R. BERSOHN AND N. M. KROLL. *Phys. Rev.*, **91**, 1257–62 (*Sept.* 1, 1953).

In this paper the fourth-order radiative corrections to the elastic scattering of an electron in the field of a fixed potential are examined, using the Dyson *S*-matrix formulation of quantum electrodynamics. The result can be represented as an addition to the interaction energy density of the electron with the external potential:

$$-ie\bar{\psi}(x)\gamma_\mu\psi(x)\Box^2/\kappa^2 A^e_\mu(x)[(\alpha^2/4\pi^2)(0 \cdot 52 \pm 0 \cdot 21)],$$

plus the anomalous magnetic moment already known. The contributions that arise from the vacuum-polarization currents are omitted. This term calculated contributes to the level shift in a hydrogenic atom an energy of

$$(\alpha^4 Z^4/n^3)\ \mathrm{Ry}\,\delta_{l,0}[(4/\pi^2)(0 \cdot 52 \pm 0 \cdot 21)].$$

For the $2S$ level of hydrogen this is $0 \cdot 24 \pm 0 \cdot 10$ Mc/s. A.

539.153.4 : 537.56

700. The calculation of auto-ionization probabilities. I. Perturbation methods with application to auto-ionization in helium. B. H. BRANSDEN AND A. DALGARNO. *Proc. Phys. Soc.* [*London*] *A*, **66**, 904–10 (*Oct.*, 1953).

Earlier calculations for auto-ionization probabilities using time-dependent perturbation methods are critically reviewed and improved methods are developed. These are applied to the calculation of the auto-ionization probabilities for certain doubly excited states of helium. The calculated probabilities lie in general between 10^{14} and $10^{15}\ \mathrm{sec}^{-1}$, confirming previous results. The evaluation of certain integrals involving Coulomb functions is described in an appendix. A.

539.153.4 : 537.56

701. The calculation of auto-ionization probabilities. II. A variational method for radiationless transitions with application to the $(2s^2\ {}^1\mathrm{S}$–$(1sks)^1\mathrm{S}$ transition of helium. B. H. BRANSDEN AND A. DALGARNO. *Proc. Phys. Soc.* [*London*] *A*, **66**, 911–20 (*Oct.*, 1953).

A variational method is developed for the calculation of radiationless transition probabilities, and

applied to the $(2s)^2\ ^1S$–$(1sks)^1S$ transition of helium. The calculated probability of $1\cdot5$ or $1\cdot1\times10^{14}$ sec^{-1} agrees well with the values 7 or 4×10^{14} sec^{-1} found by previous perturbation calculations. The identification of certain helium lines in the vacuum ultraviolet is discussed. A.

539.155.2

702. Chlorine isotope separation by thermal diffusion. A. Z. Kranz and W. W. Watson. *Phys. Rev.*, **91**, 1469–72 (*Sept.* 15, 1953).

From "two-bulb experiments" the thermal diffusion constant α of HCl has been determined to be $+0\cdot010$ at $T_r = 685°$K and $-0\cdot009$ at $T_r = 229°$K. Such a rapid change of α and R_T with temperature and an inversion temperature at or above room temperatures seem to be characteristic of strongly polar molecules. The troublesome "memory effects" of HCl in a mass spectrometer can be eliminated by using a pin-hole leak right in the box of the ion source plus a baking out, flushing and repeated-analysis routine. Some details are given of a 6·8 metre hot-wire thermal diffusion column apparatus, having an equilibrium separation factor of 7, and which has provided fairly large samples of HCl enriched to 94% HCl^{37} and 62% HCl^{37} for cyclotron beam targets and other experiments. A.

539.155.2 : 541.14

703. The photochemical separation of isotopes. B. H. Billings, W. J. Hitchcock and M. Zelikoff. *J. chem. Phys.*, **21**, 1762–6 (*Oct.*, 1953).

A method of successfully separating mercury isotopes by a photochemical process is described. The method involves the use of a monoisotopic resonance lamp as the source of light for the photochemical reaction. In this particular case a Hg^{198} lamp was used to excite only the Hg^{198} atoms. The excited Hg atoms react with water vapour to produce enriched mercuric oxide. In the first experiments an enrichment factor of $1\cdot5$ was obtained. The analysis of the isotopes was undertaken by the use of multilayer dielectric Fabry–Perot interferometers. A.

RADIOACTIVITY : α- β- AND γ-RAYS 539.16

539.16

704. Radioactive charging effects with a dielectric medium. P. Rappaport and E. G. Linder. *J. appl. Phys.*, **24**, 1110–14 (*Sept.*, 1953).

A process is described in which radioactive radiation traverses a solid dielectric medium to charge a collector electrode. This process offers a simple method of studying effects of radiation on matter such as bombardment-induced conductivity, second emission, charge soakage and radiation absorption. Typical data are given. Possible application of this process for the construction of a current or voltage source for use in electronic devices is discussed. A.

539.16.08

705. Deposition of airborne radioiodine vapour. A. C. Chamberlain and R. C. Chadwick. *Nucleonics*, **11**, 22–5 (*Aug.*, 1953).

I^{131} was released in the atmosphere by evaporation from a fine mist of CCl_4 at a height of 50 cm. The airborne dosage (time integral of the concentration of activity) was measured by air samplers at heights of 50 and 25 cm. The activity deposited on unit area of filter papers, placed on the ground, and on grass, was measured. In the case of the grass measurement, the activity was referred to unit area of ground from which the grass was close-mowed and collected. A velocity of deposition, defined as the ratio of deposited activity to airborne dosage, was derived in all cases. This quantity was about three times as great for the grass as for filter paper, but separate experiments in which individual leaves of plants and similar shapes of filter paper were exposed to active air streams, indicated that the velocity of deposition was greater for the filter papers. Assuming a maximum permissible concentration of 10^{-4} μc/g, in grass pasture, it is deduced that the average airborne concentration should not exceed 10^{-12} μc/cm^3.

L. R. SHEPHERD

539.16.08

706. Monitoring of liquids for radioactivity. W. M. Hurst. *Nucleonics*, **11**, 34–7 (*Aug.*, 1953).

A continuous-flow liquid monitor, with a sensitivity of 3×10^{-6} μc/cm^3 (for Sr^{89}), is described. A special feature of the instrument is that the active liquid is injected tangentially at the wall of a vertical cylinder, around which it flows as a rotating cylindrical wall separated from the thin-wall axially-mounted Geiger counter by an air gap. A very thin wall (0·7 mg/cm^2) counter, suitable for both α and low-energy β-particle counting, is described. This employs a continuous-flow filling of 10% methane and 90% argon.

L. R. SHEPHERD

539.16.08

707. On the geometry of angular correlation experiments. E. Breitenberger. Letter in *Proc. Phys. Soc.* [*London*] *A*, **66**, 846–7 (*Sept.*, 1953).

The integrals $\int_0^x P_n(\cos\theta)\sin\theta\, d\theta$ occurring in the correction for finite counter size are given for $n = 0$ to 8. W. J. SWIATECKI

539.163

708. Radiations from Zr^{89}. F. J. Shore, W. L. Bendel, H. N. Brown and R. A. Becker. *Phys. Rev.*, **91**, 1203–11 (*Sept.* 1, 1953).

A betatron-induced γ, n reaction on Zr^{90} has been found to produce a third branch in the decay of the 4·4 min state of Zr^{89}. The new branch includes a 1·53 MeV γ-ray (8% as intense as the 588 keV γ-ray) coincident with positrons of approximately 850 keV maximum energy. These particles ($\log ft = 4\cdot2 \pm 0\cdot1$) are in competition with the 2·4 MeV positron group ($\log ft = 6\cdot9 \pm 0\cdot3$) emitted in the decay, to the ground state of Y^{89}, of the 4·4 min Zr^{89m}. Anomalous behaviour of the comparative half-lives is indicated, since both the 2·4 MeV and the 901 keV, 79 hr positron transitions are thought to be allowed. $K/(L + M)$ conversion ratios for the 4·4 min, 588 keV and the 79 hr, 913 keV γ-radiations are, respectively, $5\cdot4 \pm 0\cdot7$ and 7 ± 2. A ten-channel scintillation spectrometer, based on a cathode-ray tube, light pipes, and photomultiplier tubes, to effect pulse-height selection, is also described. A.

539.163

709. Radiations of Ra^{227}. J. P. BUTLER AND J. S. ADAM. *Phys. Rev.*, **91**, 1219–21 (*Sept.* 1, 1953).

Ra^{227} has been prepared by the slow neutron irradiation of Ra^{226} in the NRX reactor. Ra^{227} is a β^- emitter with a half-life of $41{\cdot}2 \pm 0{\cdot}2$ min and with a β^- end point of $1{\cdot}31 \pm 0{\cdot}02$ MeV. γ-rays of 291 and 498 keV were observed with a scintillation spectrometer. The cross-section for the reaction $Ra^{226}(n, \gamma)Ra^{227}$ was found to be 23 barns. A.

539.163

710. The branching ratio of potassium 40. R. D. RUSSELL, H. A. SHILLIBEER, R. M. FARQUHAR AND A. K. MOUSUF. *Phys. Rev.*, **91**, 1223–4 (*Sept.* 1, 1953).

This was measured by determining the argon and potassium content of potassium feldspars of accurately known ages. The results obtained for five samples differing in age by more than a factor of five are all consistent within the limits of error with a branching ratio of $0{\cdot}060 \pm 0{\cdot}006$ when a total decay constant of $0{\cdot}54 \times 10^{-9}$ year^{-1} is assumed. The results indicate that loss of argon from these samples during geological time is unlikely. A.

539.163.1

711. The half-life of thallium-204. G. HARBOTTLE. *Phys. Rev.*, **91**, 1234 (*Sept.* 1, 1953).

The value $4{\cdot}0 \pm 0{\cdot}1$ years is given. A.

539.163.1

712. Half-value periods for the decay of aluminium-26, aluminium-25 and nitrogen-13. J. L. W. CHURCHILL, W. M. JONES AND S. E. HUNT. Letter in *Nature* [*London*] **172**, 460 (*Sept.* 5, 1953).

These were measured using a 9-channel scalar recording the counts from a G.M. tube in 9 successive equal periods after irradiation of Mg^{25}, Mg^{24} and C^{12} respectively with resonance protons; the values obtained were: Al^{26}, $6{\cdot}68 \pm 0{\cdot}11$; Al^{25}, $7{\cdot}62 \pm 0{\cdot}13$; and N^{13}, $602{\cdot}9 \pm 1{\cdot}9$ sec.

A. O. STANESBY

539.163.1

713. A new determination of the half-life of Am^{242m}; the problem of counting short-lived activities. T. K. KEENAN, R. A. PENNEMAN AND B. B. MCINTEER. *J. chem. Phys.*, **21**, 1802–3 (*Oct.*, 1953).

The half-life of Am^{242m} has been redetermined to yield a value of $16{\cdot}01 \pm 0{\cdot}02$ hr (99% confidence level). A simple relationship is developed between experimentally measured average counts/minute and true dN/dt; a convenient rule of thumb states that there is $<0{\cdot}1\%$ error between average disintegration rate (finite counting interval) and dN/dt (at the midpoint of the counting interval) when the counting interval does not exceed 20% of the half-life. A.

539.163.1 : 539.166

714. Upper limit of the mean life of the 6·13 MeV excited state of oxygen 16. S. GORODETZKY, R. ARMBRUSTER, A. GALLMANN, A. KNIPPER AND T. MULLER. *C.R. Acad. Sci.* [*Paris*] **237**, 45–7 (*July* 6, 1953) *In French.*

Measurements of delayed α–γ coincidences in the reaction $F^{19}(p, \alpha)O^{16*}(\gamma)O^{16}$ indicated a half-life for the 6·13 MeV excited state of $O^{16} \lesssim 10^{-9}$ sec.

A. O. STANESBY

539.163.1 : 539.166

715. Lower limit for the lifetime of the 665-KeV excited state of Mo^{97}. F. R. METZGER AND W. B. TODD. Letter in *Phys. Rev.*, **91**, 1286–7 (*Sept.* 1, 1953).

This was estimated from measurements on the nuclear resonance scattering of the 665 keV M_1 γ-ray; for Zr and Mo scatterers the counting rates were identical within the experimental error of 2%. The half-life is $\gtrsim 1{\cdot}5 \times 10^{-12}$ sec, which is $\sim$10 times the theoretical, Weisskopf value. A. O. STANESBY

539.163.2 : 539.166

716. Decay of K^{42}. B. KAHN AND W. S. LYON. *Phys. Rev.*, **91**, 1212–13 (*Sept.* 1, 1953).

The γ-spectrum of 12·44 hr K^{42} has been examined using a NaI(Tl) γ-ray spectrometer. One γ-ray of energy 1·5 MeV has been found; the fraction of the decay proceeding through this transition is $0{\cdot}200 \pm 0{\cdot}010$. A.

539.164.2

717. On the formation of alpha-particles in radioactive nuclei. S. JHA. *Proc. Indian Acad. Sci. A*, **36**, 472–81 (*Dec.*, 1952).

The factors by which the calculated half-lives of the α-disintegration of odd-even, even-odd and odd-odd nuclei deviate from the observed ones cannot all be explained by the α-particles carrying away a large angular momentum or by the unusual contraction in the nuclear radius due to structural peculiarities. The departure is attributed to the probability of the formation of α-particles before emission. In this paper, an estimate of the relative probability of the formation has been made on the shell-model and on the assumption that an α-particle is formed out of two neutrons and the two protons when they all have the same angular momentum. The α-decay of Po^{212}, Po^{210} and Bi^{211} and that of the two long-lived states of Po^{211} is discussed. A.

539.165

718. Absorption coefficients in air-equivalent substances for β-emitting radioisotopes. K. SOMMERMEYER AND K. H. WAECHTER. *Z. angew. Phys.*, **5**, *No.* 7, 242–8 (1953) *In German.*

Measurements have been made of the variation with distance in air of dosage rates from point sources of S^{35} and I^{131}, and absorption coefficients are given. Electron energy distribution curves for I^{131}, S^{35} and P^{32} are given at various distances in air from the sources. The absorption of β-rays in air is discussed theoretically and it is shown that for low energy β-emitters (S^{35}, I^{131}) the fall-off in ionization with distance from the source is almost exponential. For P^{32} the fall-off is more rapid. Energy absorption for homogeneous electron beams of 2 MeV is compared with that for these isotopes. D. V. MABBS

539.165.08

719. Film measurement of beta-ray depth dose. E. TOCHILIN AND R. GOLDEN. *Nucleonics*, **11**, 26–9 (*Aug.*, 1953).

The dose deposited by β-rays at various depths in cellulose acetate film base and in aluminium absorbers was measured by the film method. Results obtained were in substantial agreement with measurements

made by means of an extrapolation ion chamber, the effect of energy dependence of the response of the emulsions being offset by the establishment of an equilibrium spectrum in the energy of the electrons penetrating the absorber. L. R. SHEPHERD

539.165.08

720. Experimental analysis of the specific activity. Y. Saji, M. Sakisaka and K. Miyake. *J. Phys. Soc. Japan*, **8**, 580–3 (*Sept.–Oct.*, 1953).

In order to measure the absolute number of β-particles from samples by an end-window G.M. counter, the effects of self-absorption and self-scattering of β-rays in samples should be eliminated. Since apparent number of counts of β-rays from samples is generally affected by the effects above mentioned, the curve of the specific activity against the thickness of samples shows a maximum at a certain point and gradually decreases as the thickness of samples increases. The authors analysed this curve and tried to formulate it in a mathematical form, of which experimental verification in the case of silver samples activated by slow neutrons has been obtained. A.

539.165.2

721. Cross terms in allowed shape β-spectra. J. P. Davidson and D. C. Peaslee. *Phys. Rev.*, **91**, 1232–3 (*Sept.* 1, 1953).

A statistical analysis is made of allowed shape β-spectra to determine the magnitude of any $1/W$ terms that may be present. Both allowed and first forbidden spectra are analysed; only the allowed spectra are discussed. It is concluded that the (T, A) mixture in β decay is $\lesssim 4\%$. Unfortunately only one measurement can be used for the (S, V) mixture, and it does not limit the mixture to less than $\sim 10\%$. For neither (T, A) nor (S, V) is the mixture significantly different from zero. A.

539.165.2

722. The linear combination in β decay. D. C. Peaslee. *Phys. Rev.*, **91**, 1447–57 (*Sept.* 15, 1953).

Empirical evidence on the shapes of first- and second-forbidden spectra is surveyed to determine the linear combination of invariants in the β-decay interaction. Absence of $1/W$ terms in allowed shape first-forbidden spectra excludes combinations SA and VT. Spectrum shapes for $\Delta I = 2$, no, transitions exclude VA and indicate that for negatron emission the relative algebraic sign of the terms is $(S - T)$. These spectra also indicate the need for considerable correction of nuclear matrix element estimates because of the presence of pseudoscalar-coupled forces in the nucleus. Extrapolation of these empirical corrections to the case of RaE shows that the full linear combination should be $[S - T + (1/\delta)P]$, where δ is positive and of order unity. Arguments based on symmetry principles indicate that the correct interaction should in fact be $(S \pm T + P)$, where $\pm$ refers to $\beta^{\pm}$ emission. The effects of the difference in sign of the T term should in principle be observable. This law for β decay is compared with the decay of the μ-meson, and it is found that if the linear combinations are the same, the coupling constants also have identical absolute values. The mean coupling constant is $|f| = 1{\cdot}44 \times 0{\cdot}04 \times 10^{-49}$ erg cm^3. The chief experimental doubt concerns the μ-meson spectrum, which is expected to go through zero at its end point if the β and μ interactions are identical. It appears possible to deduce the combination $(S - T + P)$ uniquely from the postulates that the neutrino field is (1) unique; (2) massless; (3) part of a universal four-particle interaction. A.

539.166

723. The neutron capture γ-rays from potassium. G. A. Bartholomew and B. B. Kinsey. *Canad. J. Phys.*, **31**, 927–31 (*Sept.*, 1953).

The capture γ-rays from potassium have been re-examined with greater resolution than was used in previous experiments [Abstr. 2671 (1953)]. The upper end of the spectrum has been carefully studied both with a sample of natural potassium carbonate and with another in which the potassium was enriched in K^{40}. From a comparison of the spectra two γ-rays with energies of $9{\cdot}39 \pm 0{\cdot}06$ and $8{\cdot}45 \pm 0{\cdot}02$ MeV are assigned to capture by that isotope. The strong γ-ray at $7{\cdot}757 \pm 0{\cdot}008$ MeV previously ascribed to the ground state transition in K^{40} is now found to represent a transition to a low-lying excited state in that nucleus. A.

539.166

724. On the low excited state of Li^7. N. W. Tanner and R. G. Uebergang. *Austral. J. Phys.*, **6**, 357–9 (*Sept.*, 1953).

It is shown that isotropy through multiple interference does not depend on the populations of the sub-states, i.e. on the way in which the decaying state is formed or observed. Applied to the 478 keV level of Li^7, although an $E2$ intensity of $0{\cdot}04 \times M1$ intensity is considered unlikely, there may be an unexpected effect causing isotropy of the 478 keV γ-radiation by multipole interference; assignment of spin $\frac{1}{2}$ to this state does not seem to be completely beyond doubt. A. O. Stanesby

539.166

725. Gamma-ray spectrum of As^{77}. F. Rasetti and E. C. Booth. *Phys. Rev.*, **91**, 1192–3 (*Sept.* 1, 1953).

The γ-ray spectrum following the β-decay of As^{77} was investigated by means of a scintillation spectrometer. The following γ-ray energies (in keV) and intensities (quanta per disintegration) were observed: 88(0·003); 155(~0·002); 243(0·023); 528(0·007). Coincidence experiments show that the 88- and 155-keV lines are emitted in cascade, while the other two lines do not coincide with any other. A level diagram for the product nucleus Se^{77} is suggested. A.

539.166

726. Radiations from arsenic 77 and germanium 71. B. L. Saraf, J. Varma and C. E. Mandeville. *Phys. Rev.*, **91**, 1216–18 (*Sept.* 1, 1953).

The radionuclide As^{77} has been shown by scintillation spectrometry to emit γ-rays of energies 32, 87, 160, 247, 270 and 520 keV. It is estimated that these quanta are associated with β-ray branches totalling about 2·5% of the total β-radiation. The continuous γ-ray spectrum accompanying orbital electron capture

in Ge^{71} has been shown to have an end point at 225 ± 12 keV. Log *ft* is calculated to be 4·4 ($\Delta I = 0$, 1; no), consistent with assignment of spin ½ to the ground state of Ge^{71} in accord with the theory of the shell model. Some data relative to γ-rays from Os^{193} and Ge^{77} are included. A.

539.166

727. Gamma-rays, X-rays and bremsstrahlung from Tm^{170} sources. K. Lidén and N. Starfelt. *Ark. Fys.*, **7**, *Paper* 9, 109–16 (1953).

The spectral distribution of the electromagnetic radiation from a thin Tm^{170} source placed between Tm radiators of various thickness was investigated using a scintillation spectrometer. The experimental results have been used in a calculation of the relative intensities of the γ-rays, the X-rays and the bremsstrahlung from homogeneously activated Tm^{170} sources. The calculated distribution of the radiation from a Tm^{170} source, 1·0 g/cm², shows good agreement with experiments. With a Tm^{170} source, 150 mg/cm², the intensity of the continuous external bremsstrahlung excited by the β-particles in the source, amounts to 29% of the total intensity. With 1·0 g/cm² the spectral composition is 10% 84 keV γ-rays, 47% Tm + Yb *K* X-rays and 43% bremsstrahlung. A.

539.166 : 539.172.4

728. Gamma rays from interaction of 14-MeV neutrons with various materials. V. E. Scherrer, R. B. Theus and W. R. Faust. *Phys. Rev.*, **91**, 1476–8 (*Sept.* 15, 1953).

Experiments have been performed to observe the pulse-height distribution produced in a single crystal spectrometer by γ-radiation arising from bombardment of various materials with 14-MeV neutrons. Various γ-ray lines have been identified and estimates made of the total cross-section for γ-ray production. A.

539.166 : 578

729. Measurement of the γ-radiation from the human body. P. R. J. Burch and F. W. Spiers. *Nature* [*London*] **172**, 519–21 (*Sept.* 19, 1953).

Four large ionization chambers at 13 atm. pressure are connected through a cosmic-ray balancing circuit to an electrometer. The chambers and patient are surrounded with 2 ft water shielding, and sensitivity permits measurement to ±2 mμg, i.e. 15% of normal body content, in a 2 hr period. α-rays from walls of the chambers are almost eliminated by recombination and the apparatus is of comparable accuracy to G.M. counter methods. F. T. FARMER

539.166 : 578

730. Determination of total body radioactivity using liquid scintillation detectors. F. Reines, R. L. Schuch, C. L. Cowan, Jr, F. B. Harrison, E. C. Anderson and F. N. Hayes. *Nature* [*London*] **172**, 521–3 (*Sept.* 19, 1953).

The liquid scintillator is placed in a cylindrical chamber surrounding the patient and the fluorescence is picked up by 45 photomultipliers in parallel. The overall counting efficiency for a γ-ray source at the centre is 50% and the background counting rate 800 per sec. Results confirm that most of the activity in the body is K^{40}, and radium can be measured down to 1 mμg. F. T. FARMER

539.166.08

731. Gamma-ray intensity measurements by means of a NaI(Tl) scintillations spectrometer. M. J. Sterk and A. H. Wapstra. Letter in *Physica*, **19**, 669–70 (*July*, 1953).

Theoretical curves are given, showing the dependence of photopeak counting efficiency on crystal absorption coefficient and on distance between source and crystal. The ratio of escape peak to photopeak area (corrected for Auger effect) is also given, as a function of γ-ray energy. J. J. WILKINS

539.166.08

732. Housing for Co^{60} gamma-ray source for experimental work. R. F. Firestone and J .E. Willard. *Rev. sci. Instrum.*, **24**, 904–6 (*Oct.*, 1953).

A relatively simple housing for experimental work with multicurie radioactive sources consists of a lead turret on a low table, the volume below the table being shielded on three sides by stationary shielding and in front by a rolling lead door. The source capsule is screwed on to the end of a rod passing through vertical holes in the turret and the table. The source can be positioned in the centre of the turret when not in use and, when desired, lowered to any position adjacent to experimental equipment below the table. Using a 40-curie Co^{60} source and an annular glass irradiation vessel, an average γ-ray intensity of 2×10^5 r/hr is obtained in a 5 ml volume of liquid. A.

539.166.08

733. Gamma-ray measurements by the magnetic analysis of Compton electrons. J. W. Motz, W. Miller, H. O. Wyckoff, H. F. Gibson and F. S. Kirn. *Rev. sci. Instrum.*, **24**, 929–37 (*Oct.*, 1953).

A magnetic spectrometer has been constructed which can be used to determine photon intensities and energies over an energy range of approximately 0·2 to 12 MeV. Over this energy range, the detection efficiency of the spectrometer is such that a monoenergetic photon flux density of the order of 10^5 photons per cm² will produce one count. The instrument measures the momentum distribution of Compton electrons ejected from a thin beryllium foil into a small solid angle in the direction of the incident photon beam. A method of converting these measurements to corresponding photon intensities and energies is presented. The calculations necessary to convert to photon intensities are based on the Klein–Nishina formula, and include the effects of scattering and energy loss of the electrons in the foil. The spectrometer was calibrated from (*a*) the line shapes produced when the γ-rays from the radioactive sources Cs^{137} (0·661 MeV) and Na^{24} (1·37 MeV, 2·76 MeV) were incident on the foil and (*b*) the intensity measurements of these sources, obtained with an ionization chamber. A.

539.166.08

734. Gamma-ray spectroscopy. S. C. Curran. *Advances in Phys.*, **2**, 411–49 (*Oct.*, 1953).

A critical review of available experimental techniques. Discussion of the principles of the methods

is followed by detailed consideration of proportional tube, scintillation, magnetic and bent crystal spectrometers. Pair spectrometers, and the problem of detecting low-energy electrons, are discussed briefly.

J. J. WILKINS

539.166.08 : 537.531.08

Small-volume dosimeter for X-rays and gamma-rays. *See Abstr.* 505

539.166.2

735. Effect of the electric quadrupole interaction on the γ–γ directional correlation in Cd^{111}. III. H. ALBERS-SCHÖNBERG, K. ALDER, O. BRAUN, E. HEER AND T. B. NOVEY. Letter in *Phys. Rev.*, **91**, 1287 (*Sept.* 1, 1953).

For Pt II, see Abstr. 7103 (1953). The results of measurements on metallic indium single crystals are compared with theory, and the interaction strength is deduced. Using crude estimates of the electric field gradient, a nuclear quadrupole moment $Q \sim 5 \times 10^{-25}$ cm^2 is deduced. J. J. WILKINS

539.166.2

736. Coincidence investigation of the spectrum from $^{214}_{83}$Bi(RaC). F. DEMICHELIS AND R. MALVANO. Letter in *Nuovo Cimento*, **9**, 1106–8 (*Nov.*, 1952).

Detection of γ–γ coincidences, showing anisotropic angular correlation, is reported. J. J. WILKINS

539.166.75

737. Gamma-ray attenuation. I. Basic processes. U. FANO. *Nucleonics*, **11**, 8–12 (*Aug.*, 1953).

The interactions between photons and matter and their influence in the attenuation of beams of γ-radiation, are outlined. Energy and mass absorption coefficients for γ-radiation between 0·1 and 10 MeV, in water, Al, Fe and Pb are tabulated. L. R. SHEPHERD

539.166.75

738. Gamma-ray attenuation. II. Analysis of penetration. U. FANO. *Nucleonics*, **11**, 55–61 (*Sept.*, 1953).

The penetration of γ-radiation through great depths of homogeneous media is discussed. Equations are given for the distributions in energy and direction of secondary photons, resulting from an infinite uniform distribution of monoenergetic sources. The accumulation of secondaries at moderate and deep penetration distances is considered and build-up factors are tabulated for a number of materials in the cases of plane-collimated and point isotropic sources of primaries with a range of energies up to 10 MeV. L. R. SHEPHERD

539.166.8

739. Inner bremsstrahlung and the magnetic moment of the neutrino. J. WENESER. Letter in *Phys. Rev.*, **91**, 1025 (*Aug.* 15, 1953).

A relativistic calculation of the contribution of the magnetic moment to bremsstrahlung gives a finite result for zero neutrino rest mass [contrast Hellund, Abstr. 6211 (1953)] and shows that this is a less sensitive test for an upper limit to the magnetic moment than the ionization results. [Bethe, *Proc. Cambr. Phil. Soc.*, **31**, 108 (1935).] W. J. SWIATECKI

539.166.8

740. Bremsstrahlung from P^{32} betas. M. GOODRICH, J. S. LEVINGER AND W. PAYNE. *Phys. Rev.*, **91**, 1225–8 (*Sept.* 1, 1953).

A NaI scintillation spectrometer was used to study the spectral distribution of bremsstrahlung from P^{32} betas stopped in brass. Experimental measurements are compared with calculations based on the theoretical photon distribution, corrected for the response of the crystal. The experimental and calculated curves agree within 10% for photon energies from 50 to 1100 keV. A.

539.166.8

741. Cerenkov radiation from a Co^{60} source in water. J. A. RICH, R. E. SLOVACEK AND F. J. STUDER. *J. Opt. Soc. Amer.*, **43**, 750–2 (*Sept.*, 1953).

The spectral distribution of the Cherenkov radiation induced in deionized water by γ-rays from Co^{60} has been obtained. A 3400-curie Co^{60} source provided adequate light emission in the water surrounding it to allow a direct measurement with a grating spectrometer. In the observed spectral range, 3200 Å to 6000 Å, the spectral distribution is in agreement with the prediction of the Frank and Tamm theory and is offered as a quantitative check on this theory. A.

539.166.83

742. Auger peaks in the energy spectra of secondary electrons from various materials. J. J. LANDER. *Phys. Rev.*, **91**, 1382–7 (*Sept.* 15, 1953).

The energy spectra of secondary electrons from carbon, beryllium, aluminium, nickel, copper, barium, platinum and the oxides of beryllium, aluminium, nickel, copper and barium have been measured with equipment of high stability and sensitivity. Characteristic peaks due to Auger electrons emitted as a result of absorption of a valence electron by an excited X-ray level were observed for all these materials. The peaks exhibit structure which is of some theoretical interest. The structure can be related to the distribution in energy of electrons in the valence band, and it complements that observed in soft X-ray emission work. Since the emission of the Auger electron is not subject to the selection rules governing the emission of X-radiation, additional information can be obtained from the Auger electron energy distribution. Excitation of Auger peaks by a beam of low-velocity electrons provides an interesting technique for surface analysis. "Plasma" peaks of the type reported by Ruthemann, and interpreted by Pines and Bohm, were also observed. A.

539.167.3

743. On the use of stable and radioactive isotopes as indicators. M. AGENO. *Nuovo Cimento*, **9**, *Suppl. No.* 2, 108–18 (1952) *In Italian.*

A survey, without references. Discusses the requirements and difficulties, with examples and applications. F. R. HOLT

539.167.3

744. The preparation of chromium–51 of high specific activity. G. HARBOTTLE AND A. G. MADDOCK. *J. chem. Phys.*, **21**, 1686–7 (*Oct.*, 1953).

A procedure is given whereby chromium-51 of high specific activity may be separated from pile-bombarded potassium chromate. A.

539.169

745. Studies of bond rupture in the decay of RaD as tetramethyl lead. R. R. Edwards, J. M. Day and R. F. Overman. *J. chem. Phys.*, **21**, 1555–8 (*Sept.*, 1953).

Studies of bond rupture in tetramethyl lead caused by the beta decay of Pb^{210}(RaD) were made in solution and in vapour phase. The apparent bond rupture did not show the simple concentration dependence predicted for condensed systems by the cage hypothesis. Vapour phase results were consistent with those from solution in indicating failure of bond rupture in the primary beta and internal conversion processes. Indications are that bond rupture results from secondary processes involving neighbouring atoms following the decay process. A.

NUCLEAR REACTIONS 539.17

539.17

746. Recent advances in nuclear physics. J. Cockcroft. *Brit. J. appl. Phys.*, **4**, 289–97 (*Oct.*, 1953).

The lecture on which this is based was mainly concerned with recent advances in high-energy nuclear physics. The synchro-cyclotrons built since the war are enabling studies to be made on the interaction of high-speed nucleons with nuclear matter and on the interaction of individual nucleons. This interaction is related to nuclear forces and in a way not yet understood. The interaction of nucleons produces π-mesons in large quantities and the interaction of these mesons and their decay product the μ-meson with nuclei is now producing important new information. The production of π-mesons by the photonuclear effect has now been studied at energies up to about 350 MeV. The frontiers of nuclear physics now merge with cosmic-ray physics. Cosmic-ray workers have discovered heavier mesons, τ, χ, κ and V, and some of these are produced by nucleons of energies of the order of 5 BeV. The Brookhaven proton synchrotron now produces protons of 2·3 BeV energy and a new strong focusing principle seems to make feasible machines for energies up to 100 BeV. Cosmic-ray studies extend, however, out to energies of the order of 10^{17} eV. An account is given of some new phenomena discovered at Harwell which are believed to be due to such high energy events. Whilst this work in the high-energy field continues, experiments with lower-energy nucleons are continuing to add to our knowledge of nuclear structure and the evidence for the shell model continues to accumulate. A.

539.17 : 523.877

The effect of electron screening on thermonuclear energy generation. *See Abstr.* 40

539.172

747. Nuclear reactions between heavy nuclei. W. H. Bennett. *Rev. sci. Instrum.*, **24**, 915–16 (*Oct.*, 1953).

A method is proposed for using a modified Van de Graaff machine for producing nuclear interactions between heavy nuclei. Negative ions are accelerated from ground to a stripping material in the high potential part of the machine where many electrons are stripped from the ions, and re-accelerated towards the target material in a grounded end of the machine. A.

539.172 : 537.591.8

Nuclear reactions due to cosmic rays. *See Abstr.* 574–83

539.172 : 539.163.2

748. Accurate determinations of nuclear reaction energies. K. F. Famularo and G. C. Phillips. *Phys. Rev.*, **91**, 1195–202 (*Sept.* 1, 1953).

A precise magnetic spectrometer of the annular type is described; the focusing properties and line shapes are analysed. The use of the instrument to measure absolute particle momenta in terms of the proton magnetic moment precessional frequency and a standard length is presented for three nuclear transmutations and for the determination of the energy necessary to excite a state in Ne^{20}. The Q values obtained are: $C^{12}(d, p)C^{13}$, $Q = 2{\cdot}722 \pm 0{\cdot}004$ MeV; $O^{16}(d, \alpha)N^{14}$, $Q = 3{\cdot}119 \pm 0{\cdot}005$ MeV; and $Li^7(p, \alpha)He^4$, $Q = 17{\cdot}344 \pm 0{\cdot}013$ MeV. The energy at a resonance in the reaction $F^{19}(p, \alpha\gamma)O^{16}$ was determined to be $872{\cdot}5 \pm 1{\cdot}8$ keV. A.

539.172

749. π^- and μ^- meson-induced fission. W. John and W. F. Fry. *Phys. Rev.*, **91**, 1234–6 (*Sept.* 1, 1953).

Meson-induced fission has been studied in uranium-loaded Ilford C-2 emulsions exposed to the π^- and μ^- meson beams of the University of Chicago cyclotron. 3762 π^- endings were studied including 16 fission events. 3573 μ^- endings were studied including 7 fission events. The probability of a π^- meson ending in fission is found to be $(4{\cdot}3 \pm 1{\cdot}5) \times 10^{-3}$ in C-2 emulsion containing 0·052 g.cm^{-3} of uranium. The corresponding probability for μ^- mesons is found to be $(1{\cdot}7 \pm 0{\cdot}7) \times 10^{-3}$. Assuming that the emulsion is a homogeneous mixture and that the atomic capture probability is proportional to Z, it is found that $(37 \pm 13)\%$ of π^- absorptions in uranium produce fission and $(15 \pm 6)\%$ of μ^- absorptions produce fission. If the emulsion is considered to be composed of AgBr and gelatin with the uranium in the gelatin, the corresponding percentages are found to be $(18 \pm 6)\%$ and $(7 \pm 3)\%$. A.

539.172.11

750. A note on the $^{10}B(\alpha, p)^{13}C$ reaction. G. Manning and B. Singh. Note in *Proc. Phys. Soc.* [*London*] *A*, **66**, 842–3 (*Sept.*, 1953).

The excitation curve of the protons was studied, for bombarding energies from 0·5 to 1·5 MeV with energy resolution better than 4 keV. An energy level in N^{14} at $12{\cdot}29 \pm 0{\cdot}03$ MeV is confirmed. The proton groups at a bombarding energy of 1·5 MeV were studied at angles of 90° and 150° using nuclear emulsions, no groups were found corresponding to the level in C^{13} at 0·7 MeV, or to the known level at 3·08 MeV. With bombarding energies of 1·14 and 1·54 MeV the energy distribution of the emitted protons at 90° was examined and again no evidence was found for a level at 0·7 MeV in C^{13}. D. R. Chick

539.172.11

751. Energy levels in A^{38} from the Cl(α, *p*) reaction. A. Z. Kranz and W. W. Watson. *Phys. Rev.*, **91**, 1472–3 (*Sept.* 15, 1953).

AgCl targets containing 94% Cl^{35}—6% Cl^{37} and 62% Cl^{37}—38% Cl^{35} were bombarded with α particles. The protons resulting were observed at 90° and 0° to the incident beam, and establish excited states in the A^{38} nucleus at 2·13 ± 0·04 and 3·73 ± 0·04 MeV. No groups from A^{40} were observed. A.

539.172.11

752. Energy dependence of the cross section for the reaction $C^{12}(\alpha, \alpha n)C^{11}$. M. Lindner and R. N. Osborne. *Phys. Rev.*, **91**, 1501 (*Sept.* 15, 1953).

The cross-section *v.* energy curve for the reaction $C^{12}(\alpha, \alpha n)C^{11}$ has been investigated from threshold to 380 MeV. A.

539.172.11

753. The reaction $Li^6(\alpha, \gamma)B^{10}$. D. H. Wilkinson and G. A. Jones. Letter in *Phys. Rev.*, **91**, 1575 (*Sept.* 15, 1953).

The reaction $Li^6(\alpha, \gamma)B^{10}$ was investigated with α particles of up to 1·5 MeV. Two excited states at 4·75 ± 0·02 MeV and 5·162 ± 0·008 were observed. A known level at 5·11 MeV was not observed due to isotopic spin selection rules, but this level was assigned $J = 2$ and odd parity. The energies and relative intensity of eight γ-rays were measured and a decay scheme for the first seven excited states of B^{10} was displayed. The 5·16 MeV state was assigned $J = 2$ and even parity with $T = 1$. The 4·77 MeV state was assigned $J = 1$ and even parity. D. R. Chick

539.172.11

754. Nuclear reactions produced by the bombardment of boron by low energy alpha-particles. E. S. Shire, J. R. Wormald, G. Lindsay-Jones, A. Lundén and A. G. Stanley. *Phil. Mag.*, **44**, 1197–212 (*Nov.*, 1953).

Boron targets have been bombarded by helium nuclei of energy between 1 and 2 MeV. Resonances for production of γ-rays and protons from the reactions $B^{10}(\alpha, p)C^{13}$, of protons from $B^{10}(\alpha, p)C^{13}$ and of deuterons from $B^{10}(\alpha, d)C^{12}$ were observed at 1·13, 1·24, 1·39, 1·51, 1·64, 1·68 and 1·83 MeV. Resonances for neutrons from the $B^{10}(\alpha, n)N^{13}$ reaction were detected at 1·51, 1·64 and 2·05 MeV. Angular distributions of the particles emitted were measured at 1·13, 1·51, 1·64, 1·68 and 1·83 MeV and spins and parities of 4^-, 3^-, 4^+, 4^- and 4^+ tentatively assigned to the corresponding N^{14} levels. Spins and parities of $3/2^-$ and $5/2^+$ were confirmed for the second and third excited levels of C^{13}. Reaction cross-sections and reduced level widths were obtained for α-particle energies of 1·51 and 1·64 MeV. A resonance in the $B^{11}(\alpha, p)C^{14}$ reaction was found at 1·58 MeV α-particle energy. A.

539.172.13

755. The theory of Coulomb excitation of nuclei. K. Alder and A. Winther. Letter in *Phys. Rev.*, **91**, 1578 (*Sept.* 15, 1953).

The Ter-Martirosyan theory [Abstr. 8446 (1952)] of the excitation of a nucleus by the electric field of an impinging particle is used. The total inelastic cross-section for excitation and the angular distribution of the emitted γ-ray are calculated for a quadrupole field. P. T. Matthews

539.172.13

756. Stars produced by high energy protons in nuclear emulsions. M. Ladu. Letter in *Nuovo Cimento*, **10**, 108–10 (*Jan.*, 1953) *In Italian.*

A number of data are reported on 1190 stars observed in plates exposed to a 240 MeV proton beam. L. Pincherle

539.172.13 : 539.164

757. The angular distribution of long-range alpha particles from the proton bombardment of ^{15}N. A. V. Cohen and A. P. French. *Phil. Mag.*, **44**, 1259–68 (*Nov.*, 1953).

The angular distribution of long-range α-particles from the reaction $N^{15}(p, \alpha)$ was investigated over the range 230 keV–960 keV proton energy. It is found that the levels in O^{16} formed by resonant capture of protons of energy 340 keV and 1050 keV have spin and parity $(0, +)$ and $(1, -)$ respectively. Interference effects in the angular distribution caused by these two levels have been observed, but the phase differences necessary to account for these effects are not in full agreement with those predicted from modern dispersion theory. A.

539.172.13

758. Energy spectrum of neutrons produced in the reaction $Li^7(d, n)Be^8$ and possible excited states of Be^8. I. J. Catalá, J. Aguilar and F. Busquets. *An. Real. Soc. Espań. Fis. Quim.*, **49** (A) 131–42 (*May–June*, 1953) *In Spanish.*

The photographic method was used in the study of the neutrons produced in the disintegration of Li^7 by deuterons, in order to find out the Be^8 excitation levels. The energy distribution of neutrons is obtained by a special device, which reduces the time taken in calculating. A.

539.172.13

759. Excited states of K^{40}. W. W. Buechner, A. Sperduto, C. P. Browne and C. K. Bockelman. *Phys. Rev.*, **91**, 1502–4 (*Sept.* 15, 1953).

Using a magnetic spectrograph in conjunction with an electrostatic generator, the region of excitation in K^{40} has been studied up to 1 MeV, using the $K^{39}(d, p)K^{40}$ reaction. Excited states in K^{40} have been found at 0·032, 0·800 and 0·893 MeV, the *Q* value for the ground-state reaction being 5·576 × 0·010 MeV. A.

539.172.13

760. Triton-induced activities in magnesium and aluminium. E. Iwersen, W. S. Koski and F. Rasetti. *Phys. Rev.*, **91**, 1229–31 (*Sept.* 1, 1953).

Triton bombardment of Al^{27} and Mg^{26} gave a 6·5 min aluminium activity as a result of $Al^{27}(t, p)Al^{29}$ reaction and 21·8 hr activity of magnesium produced by the $Mg^{26}(t, p)Mg^{28}$ reaction. Studies of the X-ray spectrum of Mg^{28} showed that a 391 ± 5 keV γ-ray and possibly two more γ-rays with energies 0·95 and 1·35 MeV were associated with the decay of this isotope. A search was made for a $P^{31}(t, p)P^{33}$ reaction but negative results were obtained. A.

539.172.3

761. Photodisintegration of the deuterons at high energies. M. SASAKI. *Progr. theor. Phys.*, **8**, 557–64 (*Nov.*, 1952); erratum, **9**, 96 (*Jan.*, 1953).

The effect of tensor forces in the photodisintegration of deuterons is investigated. The calculation shows that the angular distribution can be given in the form $\{a + (b + c\cos\theta)\sin^2\theta + d\cos\theta\}$ and no other additional terms appear. A.

539.172.3

762. Nuclear photo-disintegration of B^{10} and B^{11} by γ-rays up to 31 MeV. R. MÜLLER AND P. STOLL. Letter in *Nuovo Cimento*, **9**, 1232–6 (*Dec.*, 1952) *In German.*

Cross-sections are given in graphical form as a function of γ energy. F. R. HOLT

539.172.3

763. The angular distribution and yield of nuclear photoprotons between 20 and 60 MeV from Be, C, Cu and Pb with 150 MeV γ-ray energy. H. HENDEL. *Z. Phys.*, **135**, *No.* 2, 168–76 (1953) *In German.*

The distribution is continuous from 125° to small angles, with a maximum at about 45°. With increasing proton energy the maximum moves towards a smaller angle. The increase from 125° to 90° is, for 50 MeV protons, twice that, and from 90° to the maximum it is 1·5 times that for 30 MeV protons. The cross-section for 30 and 50 MeV protons is proportional to Z. Less angular variation was found for Pb than for the others. F. R. HOLT

539.172.3

764. A selection rule for the reaction $^6Li(\gamma, d)^4He$. A. GAMBA AND V. WATAGHIN. Letter in *Nuovo Cimento*, **10**, 174–5 (*Feb.*, 1953).

It is shown, by group-theoretical arguments, that the reaction is isotopic spin forbidden for an electric dipole transition, and that electric quadrupole and magnetic dipole transitions probably favour the alternative (γ, n) and (γ, p) reactions. J. J. WILKINS

539.172.3

765. The energy dependence of the cross-section of the reaction $Li^7(\gamma, \alpha)H^3$. P. STOLL AND M. WÄCHTER. Letter in *Nuovo Cimento*, **10**, 347–9 (*March*, 1953) *In German.*

Using betatron γ's up to 15 MeV and emulsions, the cross-section was shown to have maxima at $7\frac{1}{4}$ ($?9\frac{1}{4}$ and $?5\frac{1}{4}$) MeV associated with levels in Li^7.

W. J. SWIATECKI

539.172.3

766. $Li^7(\gamma, p)He^6$ cross-section. B. L. TUCKER AND E. C. GREGG. Letter in *Phys. Rev.*, **91**, 1579 (*Sept.* 15, 1953).

The He^6 activity yield has been measured for γ-ray energies up to 19 MeV. The cross-section values deduced do not agree with values reported elsewhere [Abstr. 4356 (1953)]. J. J. WILKINS

539.172.4

767. Pile neutron capture cross sections of Co^{60*} (10·5 min.) and Co^{60} (5·25 yr.). F. BROWN, J. L. WOLFSON AND L. YAFFE. *Canad. J. Phys.*, **31**, 903–10 (*Sept.*, 1953).

Activity of approximately 105 min half-life has been detected in samples of Co^{59} irradiated at high neutron fluxes in the NRX reactor. By a study of the yield as a function of neutron flux and time of irradiation this activity was demonstrated to be due to Co^{61} (105 min) formed by neutron capture in Co^{60}. The pile neutron capture cross-sections were found to be 95 ± 45 barns and $6{\cdot}0 \pm 1{\cdot}4$ barns for the Co^{60*} (10·5 min) and Co^{60} (5·25 yr) isomers respectively. A.

539.172.4 : 539.185

Two-group neutron diffusion calculations. *See Abstr.* 790

539.172.4 : 541.15

Szilard and Chalmers effect by irradiation of hexavalent chromium in an atomic pile. *See Abstr.* 844

539.172.4 : 778.34

768. The energy spectrum of particles from stars. R. W. WANIEK AND T. OHTSUKA. Letter in *Phys. Rev.*, **91**, 1574 (*Sept.* 15, 1953).

Range distribution of particles from stars in photographic plates exposed to high-energy neutrons was investigated. The actual range of each arm of the star was determined allowing for plate shrinkage and escape. Range histograms (for 400, 1 to 5 prong events) are plotted for 0° and for 6 angular intervals of 30° between 0 and 180° with no discrimination between the different types of particles. The position of the peak of the range spectrum did not vary with angle but intensity of the peak showed a forward asymmetry. 12% of the total number of prongs could be attributed to α-particles and the peaks of the separated range distribution correspond to 6 MeV alphas and 2·5 MeV protons, indicating that the majority of events occur in the light nuclei component of the emulsion. By selecting stars with one prong of energy less than the Coulomb barrier of the heavy nuclei, the authors conclude that at least 80% of 1 and 2 prong stars and at least 95% of 3 prong stars, together with almost all 4 and 5 prong events are attributable to the light nuclei of the emulsion.

D. R. CHICK

539.172.4

769. Yield of Xe^{133} in the thermal neutron fission of U^{235}. S. KATCOFF AND W. RUBINSON. *Phys. Rev.*, **91**, 1458–69 (*Sept.* 15, 1953).

The yield of 5·27-day Xe^{133} in the thermal neutron fission of U^{235} was determined accurately by a method in which the fission rate was measured with a double chamber fission counter, and in which the disintegration rate of the chemically separated Xe was measured by gas phase proportional counting. Five separate determinations gave a mean value of $(6{\cdot}62 \pm 0{\cdot}15)$%, where the indicated error is the 99 : 1 probable error. A considerable number of possible sources of error was investigated in detail and taken into account when making the measurements and calculations. As by-products of this work, it was determined that: (1) the independent yield of Xe^{133} in U^{235} fission is not greater than 0·1% of the chain yield; (2) the independent yield of 9·15 hr Xe^{135} is about 3·5% of the total yield of the mass-135 chain; and (3) the half-life of I^{133}, as measured by a procedure which circumvented most of the interference from other nuclides, is $20{\cdot}8 \pm 0{\cdot}2$ hours. A.

539.172.4 : 518.5

770. Reactor simulators. F. E. O'MEARA. *J. appl. Phys.*, **24**, 1200–2 (*Sept.*, 1953).

Reactor kinetic equations are given together with the equations for fission product poisoning and temperature effects. A conceptual design of a reactor simulator is presented and the numerical values of the coefficients are listed. A.

ATOM AND MOLECULE BEAMS . MESONS NEUTRONS 539.18

539.18

771. Life-time of μ-mesons. B. V. SREEKANTAN. *Proc. Indian Acad. Sci. A*, **36**, 289–98 (*Oct.*, 1952).

The disintegration curves of positive μ-mesons at rest in two absorbers lead and paraffin were determined experimentally by an oscilloscopic method using cosmic-ray mesons at sea level as the source of μ-mesons. The mean life-time for positive mesons in lead is $2{\cdot}24 \pm 0{\cdot}17$ μsec and in paraffin the mean life-time is $2{\cdot}24 \pm 0{\cdot}15$ μsec. A complete description of the equipment built for this experiment is given. A.

539.18

772. Ratio of κ- to π-mesons on Fermi's theory. D. S. NARAYAN. *Proc. Indian Acad. Sci. A*, **37**, 120–6 (*Jan.*, 1953).

Fermi's theory of meson production is used to calculate the ratio of numbers of κ to π-mesons when the rest energies of the mesons cannot be neglected. N_κ/N_π is calculated with $m_\pi = 280\, m_e$ and $m_k = 1300\, m_e$ and the alternative assumptions that the κ-meson has spin $\frac{1}{2}$ and statistical weight 8 or spin 0 and statistical weight 3. Observational evidence appears to favour the latter assumption. H. ELLIOT

539.18

773. A τ-meson arising from a star. M. CECCARELLI, N. DALLAPORTA, M. MERLIN, G. QUARENI AND G. T. ZORN. Letter in *Nuovo Cimento*, **10**, 681–2 (*May*, 1953) *In Italian.*

The whole track was observed in a sandwich of plates exposed at 30 km altitude. The relations ionization-range and scattering-range lead to $m/m_{el} = 955 \pm 110$, and the study of the energy of disintegration to $m/m_{el} = 975 \pm 12$. L. PINCHERLE

539.18

774. Analysis of a τ-meson decay. M. PANETTI AND L. SCARSI. Letter in *Nuovo Cimento*, **10**, 687–90 (*May*, 1953).

The τ-meson was observed to decay in G5 nuclear plates which had been exposed for 6 hr at 25 000 m. One of the π-mesons decays in the emulsion according to the scheme $\pi^+ \rightarrow \mu^+ \rightarrow e^+$. The mass and Q values for the τ-meson are $(977{\cdot}7 \pm 17)m_e$ and $(75{\cdot}2 \pm 7)$ MeV respectively. H. ELLIOT

539.18

775. Some regularities in the masses of heavy particles. K. M. GATHA. *Proc. Indian Acad. Sci. A*, **38**, 194–8 (*Aug.*, 1953).

The proposed empirical rule $M_n = n\overline{M}$ is considered consistent with experimental observations. The mass quantum M can be identified with $m/2\alpha$. Further, the mass quantum numbers n possess the same statistical property as exhibited by the nuclear mass numbers A. The validity of this rule could be further tested as more particle masses are measured with greater accuracy. A.

539.18

776. The spectrum and half-life of the κ meson. J. P. DAVIDSON. Letter in *Phys. Rev.*, **91**, 1020 (*Aug.* 15, 1953).

Assuming a $(S \pm T + P)$ interaction between the 4 particles in $\kappa^\pm \rightarrow \mu^\pm + 2\gamma$ or $\kappa^\pm \rightarrow e^\pm + 2\nu$ (Peaslee: to be published in *Phys. Rev.*) and a coupling constant derived from β decay, the $\frac{1}{2}$-life against κ mass and the energy spectrum of the decay particle are plotted for both modes of decay. W. J. SWIATECKI

539.18

777. Selection rules for decays of π-mesons and V-particles. T. HAMADA AND M. SUGAWARA. *Progr. theor. Phys.*, **8**, 363–79 (*Sept.*, 1953).

Making use of the general principle of invariance under space rotation and inversion, the decay of a π-meson into two fermions and a V-particle (assuming spin $\frac{1}{2}$) into one boson and one fermion are investigated. The subject of interest is: whether any of these decay processes can be made forbidden by assigning appropriate parities to various fermions, as has been remarked by Yang and Tiomno (1950). It is found that there exists no such possibility, that is, there is no reasonable assignments of parities which make any processes forbidden. This result is re-examined in the light of the charge-independence hypothesis, in which π-meson fields are considered to interact charge-symmetrically with nucleon and lepton fields. It is found, however, that the introduction of this hypothesis does not better the situation at all. Several definite conclusions are drawn on the isotopic angular momenta of V-particles from this hypothesis. The possibility of a model in which μ-mesons and V-particles are assumed to be the excited states of leptons and nucleons, respectively, is discussed. A.

539.18

778. Ionization energy losses of relativistic μ mesons in gases. J. E. KUPPERIAN, JR AND E. D. PALMATIER. *Phys. Rev.*, **91**, 1186–91 (*Sept.* 1, 1953).

By means of proportional counters the ionization energy losses in gases of μ-mesons of several high energy groups have been compared with the loss for mesons at minimum ionization. It is shown that in a normal proportional counter and Geiger counter telescope arrangement as was used in this work, the effects of locally generated showers and counter-wall-generated secondary electrons tend to mask the increase in ionization loss accompanying increasing μ-meson energy. When such effects are considered, the theoretical rise as predicted by the Bethe–Bloch–Williams theory is confirmed. A.

539.18

779. Large angle scattering of negative pions in aluminium, copper, and lead. H. H. HECKMAN AND L. E. BAILEY. *Phys. Rev.*, **91**, 1237–42 (*Sept.* 1, 1953).

The total cross-sections for backscattering of 32 ± 10 MeV negative pions in Al, Cu and Pb were measured. A stripped emulsion was embedded in a semi-infinite absorber, and exposed to an incident

beam of π^--mesons. The positions and direction of mesons stopping in the emulsion were recorded. The cross-sections are proportional to the ratio of the backward flux to incident flux, both of which are observed on the same strip of emulsion. The conclusions of this investigation are: (*a*) the scattering is consistent with energy independence in the region of 32 ± 10 MeV; (*b*) the angular distribution has a maximum at 180°; (*c*) the cross-section for back-scattering is proportional to the mass number A. The total nuclear backscattering cross-sections (elastic and inelastic) for negative pions in Al, Cu and Pb are $59{\cdot}6 \pm 11$ mb, 192 ± 27 mb and 577 ± 80 mb respectively. A.

539.18

780. Graphical method for obtaining phase shifts from the experimental data on meson-nucleon scattering. J. Ashkin and S. H. Vosko. *Phys. Rev.*, **91**, 1248–51 (*Sept.* 1, 1953).

A graphical method is used for obtaining scattering phase shifts from the experimental data on meson-nucleon scattering. The method is based on the observation that the imaginary part of the amplitude for coherent forward scattering is proportional to the total cross-section for the meson scattering. The results are in agreement with a complete numerical analysis of the problem made by Fermi with the help of the high-speed electronic computer at Los Alamos. A.

539.18

781. Production of V_1^0 particles by negative pions in hydrogen. W. B. Fowler, R. P. Shutt, A. M. Thorndike and W. L. Whittemore. Letter in *Phys. Rev.*, **91**, 1287 (*Sept.* 1, 1953).

Two diffusion cloud chamber events are discussed, produced by 1·5 BeV π^--particles from the Brookhaven cosmotron. The life-times of the V_1^0 are 4×10^{-11} and 3×10^{-11} sec respectively. Momentum measurements obtained for the decay products in one of the events (450 ± 80 MeV/c for the proton and 210 ± 70 MeV/c for π^-) are in agreement with the accepted Q value of 37 MeV. G. FIELD

539.18

782. The scattering of 40-MeV positive pions by hydrogen. J. P. Perry and C. E. Angell. Letter in *Phys. Rev.*, **91**, 1289 (*Sept.* 1, 1953).

Differential cross-sections were measured at laboratory angles of 45, 60, 90, 120 and 140 degrees. The integrated total cross-section of $(10{\cdot}9 \pm 3) \times 10^{-27}$ cm^2 agrees with that obtained from an attenuation measurement [Abstr. 6235 (1953)]. G. FIELD

539.18

783. Positive π-meson production by negative π-mesons. W. F. Fry. Letter in *Phys. Rev.*, **91**, 1576 (*Sept.* 15, 1953).

This has been studied by bombarding nuclear emulsions with 220 MeV π^--mesons and analysing the observed interactions. J. J. WILKINS

539.18

784. Energy spectra of charged π-mesons produced in carbon, aluminium and copper at 90° to a 345 MeV proton beam. S. Tokunaga, K. Yuasa, K. Nishikawa and T. Isii. *J. Phys. Soc. Japan*, **8**, 571–4 (*Sept.–Oct.*, 1953).

Energy spectra of charged π-mesons produced in C, Al and Cu bombarded by a 345 MeV proton beam were obtained with nuclear emulsions. The production cross-sections of π^+- and π^--mesons from aluminium are $(5{\cdot}3 \pm 1{\cdot}2)\ 10^{-28}$ cm^2 ster.$^{-1}$ and $(1{\cdot}9 \pm 0{\cdot}8)\ 10^{-28}$ cm^2 ster.$^{-1}$ respectively. In case of copper they are $(1{\cdot}2 \pm 0{\cdot}2)\ 10^{-27}$ cm^2 ster.$^{-1}$ and $(3{\cdot}6 \pm 1{\cdot}0\ 10^{-28}$ cm^2 ster.$^{-1}$ respectively. Comparing with the cross-section of π-mesons from carbon obtained by Richman *et al.* it is found that the cross-section for charged π-meson production varies roughly as mass number A for small A. A.

539.18

785. The decay-in-flight of a heavily-ionizing τ-meson. D. B. Gayther. *Phil. Mag.*, **44**, 1297–9 (*Nov.*, 1953).

A τ-meson has been observed to decay in the gas of a cloud chamber operated without a magnetic field. The τ-meson was apparently created directly in an energetic nuclear interaction. Its energy at creation was about 100 MeV, and it lived for a proper time of $(7{\cdot}8 \pm 1{\cdot}0) \times 10^{-10}$ sec in the illuminated volume of the chamber. A.

539.18

786. Kinetic energies of V_1^0 particles. J. Ballam, D. R. Harris, A. L. Hodson, R. R. Rau, G. R. Reynolds, S. B. Treiman and M. Vidale. Letter in *Phys. Rev.*, **91**, 1019 (*Aug.* 15, 1953).

Report of an analysis of 77 V^0 cloud chamber events at 10 600 ft. A remarkably large fraction have low kinetic energies and 2 do not fit recently proposed decay schemes. W. J. SWIATECKI

539.185

787. On the scattering of polarised neutrons by protons. A. B. Bhatia and T. S. Sankaran. *Proc. Indian Acad. Sci. A*, **33**, 1–10 (*Jan.*, 1951).

The study of scattering and the consequent depolarization of a polarized beam of neutrons on being scattered by an unpolarized proton gas has been suggested earlier [Abstr. 6082 (1950)] as a means of obtaining information about *n-p* interaction. In this note a general expression for the polarization factor for the scattered neutrons has been derived in terms of phase-shifts, when the *n-p* interaction has a non-central term as well. Further it is shown that from a knowledge of the scattering and the polarization cross-sections as functions of θ and ϕ (the angle and the azimuth of scattering), it is possible to obtain all the unknown phase-shifts, which determine the scattering. This is of interest, since knowledge of the phase-shifts as functions of the energy of the particles, enables one to determine the interaction potentials themselves, at least in the first approximation. A.

539.185

788. Effects of tensor forces on the neutron-deuteron scattering. H. Horie, T. Tamura and S. Yoshida. *Progr. theor. Phys.*, **8**, 341–54 (*Sept.*, 1952).

The elastic neutron-deuteron scattering cross-section at 90 MeV is calculated, using the Born approximation. For neutron-neutron and neutron-proton interactions the potentials which give good agreement with nucleon-nucleon scattering experiments at

high energies are adopted. The Hulthén wave-function is used for the ground state of the deuteron. The results are in better agreement with experiments than calculations which do not take into account the tensor forces. A.

539.185

789. The scattering of 10 and 14 MeV neutrons by deuterons. T. C. GRIFFITH. *Proc. Phys. Soc.* [*London*] *A*, **66**, 894–903 (*Oct.*, 1953).

The angular distributions of scattering of 10 and 14 MeV neutrons by deuterons have been investigated using photographic emulsions: 1540 deuteron recoils entering the emulsion from a thin target of heavy wax placed in contact with its surface were measured. The results are shown to be in good agreement with the recent theoretical curves of Buckingham, Hubbard and Massey [Abstr. 2766 (1952)]. The errors to which the measurements are subject have been carefully considered and give a clear indication of the limitations of the photographic emulsion technique in an experiment of this nature. A.

539.185 : 539.172.4

790. Lumped reflector parameters for two-group reactor calculations. D. FIENO, H. SCHNEIDER AND R. B. SPOONER. *Nucleonics*, **11**, 16–18 (*Aug.*, 1953).

The diffusion of fast and thermal groups of neutrons in finite layers of moderating material, is treated by analogy with current flow in appropriate transmission lines. Three parameters are derived which serve to describe the behaviour of reflectors. L. R. SHEPHERD

539.185

791. Nuclear emulsion method for energy measurement of inelastically scattered neutrons. S. C. SNOWDON, M. A. ROTHMAN, D. W. KENT, JR AND W. D. WHITEHEAD. Note in *Rev. sci. Instrum.*, **24**, 876–7 (*Sept.*, 1953).

A favourable experimental arrangement is suggested, in which the emulsion is placed at the centre of an annular ring of the scattering material.

J. J. WILKINS

539.185

792. Neutron diffraction by liquid helium. D. G. HENSHAW AND D. G. HURST. *Phys. Rev.*, **91**, 1222 (*Sept.* 1, 1953).

Preliminary results of a measurement of the angular distribution of 1·08 Å neutrons scattered by liquid helium at 4·2°K over the angular range 3·8° to 31° are reported. A maximum in the scattering occurs at 21·3° ± 1°, corresponding to a peak at 3·6 Å in the radial distribution of density about any atom in the liquid. A.

539.185

793. Inelastic scattering of thermal neutrons in lead. A. W. MCREYNOLDS. *Phys. Rev.*, **91**, 1368–71 (*Sept.* 15, 1953).

The total thermal inelastic scattering cross-section of lead was measured from transmission of a single crystal, from 2–8 Å (0·02–0·0013 eV) at 80°K and 295°K, and is found to be in quantitative agreement with current theory of one-phonon process of energy exchange with the lattice. Measurements of differential cross-section at 1·08 Å (0·07 eV) are in agreement with Debye–Waller theory. Thus inelastic cross-section through the thermal range is found to fit the two theories in their ranges of validity. A.

539.185

794. Measurement of the energy of isotropic fast neutrons with Li^6 loaded plates. J. H. ROBERTS, W. O. SOLANO, D. E. WOOD AND H. B. BILLINGTON. *Rev. sci. Instrum.*, **24**, 920–4 (*Oct.*, 1953).

100 micron E1 and C2 Ilford plates loaded with enriched Li^6 were exposed to neutrons from $Li^7(p,n)Be^7$ and from $H^3(p,n)He^3$. The plates were rotated to mockup isotropic incidence. Neutron energies ranged from 200 to 1500 keV. The plates were faded and developed so as to obtain good triton-alpha discrimination. Peaks having widths from 100 to 300 keV at half-maximum were obtained, depending upon neutron energy and selection criteria. A.

539.185.7

795. Determination of the neutron-proton capture cross section. G. VON DARDEL AND A. W. WALTNER. Letter in *Phys. Rev.*, **91**, 1284 (*Sept.* 1, 1953).

Measured by mean life of neutrons in water as 0·321 ± 0·005 barns at a neutron velocity of 2200 m/sec, it is suggested that water is better suited than boron as a primary standard for cross-sections. A secondary standard was prepared in the form of 8·83 g boron per litre of water, and the measured cross-section was 0·0610 ± 0·0004 cm^2 per cm^3 of solution. D. R. CHICK

STRUCTURE OF SOLIDS 539.2

539.211

796. Transverse cracks in glass rod. E. R. W. JONES AND P. L. PRATT. Letter in *Nature* [*London*] **172**, 463–4 (*Sept.* 5, 1953).

Glass rod broken in tension showed transverse cracks which had not been propagated right across the rod. Some of these appeared to be totally enclosed. The rod probably had internal stresses, tensile in the centre and compressive at the periphery.

539.213

797. Glass and crystal. A. FIORENTINI. *Atti. Fond. Ronchi*, **8**, 278–85 (*July–Aug.*, 1953) *In Italian.*

Some of the most important theories on reticular structure of glass are briefly reviewed. A.

539.213.26 : 535.412

Mechanism of polishing glass. *See Abstr.* 355

539.215 : 539.434

798. Distortion of the crystal lattice and the sintering of metallic powders. L. I. GAL'PERINA, YA. E. GEGUZIN, B. YA. PINES AND I. V. SMUSHKOV. *Dokl. Akad. Nauk SSSR*, **88**, *No.* 2. 265–8 (1953) *In Russian.*

Lattice distortion can influence the kinetics of the sintering of powders by altering the coefficient of self-diffusion. Strains in Cu and Ni powders were measured from the broadening of lines in X-ray back-reflection photographs taken during annealing at temperatures (T) up to 400°. The change Δb in line

width was found to be approximately $t^{\beta} \exp(-\alpha/T)$ (t = time of annealing). From this the energy of activation (for Cu) was calculated as 20 kcal/mol as compared with 12 kcal/mol found for the energy of activation for the initial stages of diffusion sintering [Abstr. 7967 (1953)]. The value for self-diffusion in the solid material has been found to be 56 kcal/mol. A. L. MACKAY

539.215.2

799. Observation of the grain boundary in soap bubble raft. I. Static feature of the grain boundary. E. FUKUSHIMA AND A. OOKAWA. *J. Phys. Soc. Japan*, **8**, 609–14 (*Sept.–Oct.*, 1953).

The grain boundary is constructed in the raft by the procedure of progressively increasing the angle of disorientation between two grains. The grain boundaries observed are classified into three types with respect to the statical transition structure. At an angle of disorientation $\theta \sim 0°$, the grain boundary (type A) is constituted of dislocations all on parallel slip planes. At an angle of disorientation $\theta \sim 60°$, the grain boundary (type C) is constituted of two sorts of dislocations each on non-parallel slip planes. At an intermediate angle of disorientation, the grain boundary (type B) is composed of disordered groups of atoms or diffused holes. The mechanism of the grain boundary variation with the angle of disorientation is discussed in the light of the current theory of dislocations, where the stress is laid on the predominance of reactions between the dislocations and the relative shortage of thermal agitation. A.

539.216.1

800. Birefringence and elasticity in keratin fibres. R. D. B. FRASER. Letter in *Nature* [*London*] **172**, 675–6 (*Oct.* 10, 1953).

Non-medullated human hairs were degreased and the extension ratios and birefringence measured when they were stretched in water on the stage of a polarizing microscope. Curves of birefringence, and of load, against extension ratio are given. The experimental values of birefringence are compared with values calculated for the α-helix and pleated-sheet models of Pauling and Corey [*Proc. Nat. Acad. Sci. U.S.A.*, **37**, 729 (1951)]. The low initial birefringence in hair (*c.* 0·007) indicates that a significant fraction of the keratin is poorly oriented. The marked increase in birefringence on extension is probably due to the co-operation of crystalline fibrillar and amorphous matrix components. The form of the curves, over the range of extension ratio 1 to 1·5 (relative birefringences of 1 to 2·8) is discussed and possible explanations put forward. J. IBALL

539.217

801. Some predicted effects of temperature gradients on diffusion in crystals. W. SHOCKLEY. Letter in *Phys. Rev.*, **91**, 1563 (*Sept.* 15, 1953).

It is proposed that if in a solid, in which there exists a temperature gradient, the density of lattice defects (vacancies or interstitials) has everywhere the equilibrium value characteristic of the local temperature, there will be a diffusion flow of defects down the temperature gradient. This will produce a mass transport through the lattice towards regions of high temperature for vacancies and of low temperature for interstitials. Methods are discussed whereby such a mass transport may be observed so as to provide a means of distinguishing between vacancies and interstitials. A. D. LE CLAIRE

539.234

802. The structure of thin aluminium-silver layers. H. GÖTTSCHE AND H. RAETHER. Note in *Acta cryst.*, **6**, 568 (*June*, 1953) *In German.*

Electron diffraction photographs of layers of Al–Ag (30% Ag by weight), evaporated *in vacuo* at 450°C on rock salt, show satellite reflections. These are ascribed to the successive deposition of the α- to δ-phases of the Al–Ag diagram, which results in stacking disorders of a regular type. J. THEWLIS

539.234 : 539.4.014.13

803. The origin of stress in metal layers condensed from the vapour in high vacuum. H. P. MURBACH AND H. WILMAN. *Proc. Phys. Soc.* [*London*] *B*, **66**, 905–10 (*Nov.*, 1953).

Measurements were made of the stress in deposits of Ni, Fe, Pd, Au, Cu, Ag, Sb, Al, Bi, Mg and Zn condensed from the vapour in high vacuum on copper strips used as substrates. The stress was found to be characteristically of a tensile nature and the amount of stress different for different metals. The occurrence, nature and order of magnitude of the stress are explained as arising from the contraction of the upper regions of the growing deposit as they cool after their deposition, which takes place at a temperature generally several hundred degrees higher than the initial substrate temperature. According to this interpretation, this contraction will begin to set up a tensile stress in any stratum of the deposit as soon as the temperature of the region concerned falls below the recrystallization temperature of the deposit metal. An estimation of the stress to be expected from this cause falls in the region of the experimentally determined values. In Al a compressive stress is observed if the metal is evaporated in an imperfect vacuum, the air pressure being about 10^{-4} mm Hg or higher. Evidently appreciable oxidation of the aluminium occurs and the compressive stress is associated with the formation of the oxide between the metal crystals or included to some extent within the crystals. Results for electrodeposits are analogous. A.

539.26

804. Reversible single-crystal rocking-curve broadening. L. C. CHANG, T. A. READ AND M. S. WECHSLER. Letter in *Acta cryst.*, **6**, 567 (*June*, 1953).

The rocking curve widths of the 100 and 200 reflections from a 50 atomic % single crystal of Au–Cd which had been held at 480°C for 30 minutes and then quenched to room temperature, were measured at constant temperature as a function of time after quench. The observed broadening of the reflections with time was interpreted as due not to a spread in the value of lattice parameter, but rather to a change in the spread of orientation of mosaic blocks, a process which is considered to be related to the relaxation of the quenching stresses which remain after the rapid cooling. No broadening occurs with specimens cooled slowly from 480°C. A. D. LE CLAIRE

539.264 : 539.216

805. New method of recording fibre-diagrams. C. LEGRAND. *C.R. Acad. Sci.* [*Paris*] **237**, 573–5 (*Sept.* 14, 1953) *In French.*

X-ray fibre patterns are recorded on a film which is coaxial with the primary X-ray beam. The diffraction rings then appear as straight lines. This greatly facilitates the microphotometry of such lines, for example, for measurements of preferential orientation. The layer lines come out as ellipses. J. THEWLIS

539.27

806. Metallic grating replicas as internal standards for calibrating electron microscopes. S. R. ROUZE AND J. H. L. WATSON. *J. appl. Phys.*, **24**, 1106–9 (*Sept.*, 1953).

It was shown in Abstr. 7597 (1952) that plastic grating-replicas mounted upon $\frac{1}{8}$ in. specimen screens were practical internal standards and that they could be accurately calibrated independently by spectroscopic means. Metallic replicas of diffraction gratings have been made by a direct-stripped method. These can still be direct-stripped easily and without damage to the original grating, and the optical quality of these pre-shadowed all-metal replicas is better than that of the plastic replicas. Because of their superior optical properties, the spacing can be determined spectroscopically more conveniently and with greater accuracy. In addition, the metal-gratings are more stable than the plastic ones. The electron microscopy of the metallic replicas and the accuracy and constancy of their magnification measurement is discussed. A.

ELASTICITY . STRENGTH . RHEOLOGY
539.3/.8

539.31

807. On the definition of stress in the finite deformation theory. Y. YOSHIMURA. *J. Phys. Soc. Japan*, **8**, 669–73 (*Sept.–Oct.*, 1953).

Three kinds of stresses are considered, i.e. the stress tensor, the true and nominal stress in the finite deformation theory being considered, taking orthogonal curvilinear co-ordinates as the independent variables, the interrelations of each stress are obtained. The equilibrium equations corresponding to each definition of stress are given in the form convenient to the statical and dynamical problems respectively. The tensorial equation is more simple formally, but not substantially so. A.

539.32

808. An apparatus for measuring the dynamic shear elasticity and viscosity of solids at high audio frequencies. *J. sci. Instrum.*, **30**, 412–13 (*Nov.*, 1953).

An apparatus has been designed to measure the dynamic properties of organic glasses at high audio frequencies. The principle of the method employed was that the material, in the form of a rod, was used as the suspension of a moving coil galvanometer. Freely decaying torsional oscillations were detected and displayed as a repeating trace on a cathode-ray oscilloscope. This enabled the logarithmic decrement and frequency of the oscillations to be measured directly. Some typical results are presented. A.

539.32 : 548.0

809. Elastic properties of polycrystalline aggregates. S. BHAGAVANTAM AND T. SESHAGIRI RAO. *Proc. Indian Acad. Sci. A*, **35**, 129–35 (*March*, 1952).

The ultrasonic wedge method was used for a determination of the average values $(C'_{11})Av$ and $(C'_{44})Av$ in the case of certain polycrystalline aggregates of cubic compounds prepared by compressing finely divided powder under high pressures. The measured values are compared with the values calculated from the known single crystals constants. It is found that certain substances can be compressed till their densities closely reach the single crystal densities and in those substances the average elastic properties also closely reach the corresponding ideal values. In other cases, the compressibility of a pressed specimen depends to a marked degree upon its density. A.

539.32 : 548.7

810. Evaluation of the elastic constants of diamond from its Raman frequencies. D. KRISHNAMURTI. *Proc. Indian Acad. Sci. A*, **33**, 325–32 (*June*, 1951).

Expressions for the elastic constants of diamond have been derived in terms of the force constants calculated by Ramanathan [Abstr. 2995 (1948)] which express the interaction of any atom with its 28 neighbours. The calculated values are: $C_{11} = 9{\cdot}6 \times 10^{12}$; $C_{12} = 3{\cdot}9 \times 10^{12}$; $C_{44} = 4{\cdot}2 \times 10^{12}$ dynes/cm^2, agreeing with the values experimentally determined by Bhagavantam and Bhimasenachar [Abstr. 1039 (1947)]. A.

539.373

811. Slip lines and etchpits. S. AMELINCKX. Letter in *Phil. Mag.*, **44**, 1048–9 (*Sept.*, 1953).

Electrolytically polished specimens of Al were slightly strained and then etched. Rows of etchpits, which previous work has shown to occur at the points of emergence of dislocations [Abstr. 7286 (1953)], were found along the slip lines, not uniformly distributed, but in clusters as would be expected on Mott's theory of work hardening [Abstr. 1991 (1953)]. A. D. LE CLAIRE

539.374

812. The energy stored in metal chips during orthogonal cutting. M. B. BEVER, E. R. MARSHALL AND L. B. TICKNOR. *J. appl. Phys.*, **24**, 1176–9 (*Sept.*, 1953).

Chips of a gold–silver alloy were made by orthogonal cutting with apparatus which permitted the determination of the chip geometry and cutting forces. From these data the stresses and strains and the shear and friction energies were calculated. Three rake angles were used to obtain different shear strains. The energy stored in the chips was determined as the difference in the heat effects associated with the dissolution in liquid tin of samples of cold worked and annealed chips in an isothermal calorimeter of high precision. With increasing strain the stored energy increased, but the ratio of the stored energy to the shear energy decreased. A.

539.374

813. Deformation of copper single crystals at 300°K and 78°K. T. H. BLEWITT. *Phys. Rev.*, **91**, 1115–21 (*Sept.* 1, 1953).

Single crystals of copper were deformed at 78°K and 300°K. There was slight temperature dependence of the critical shear stress in this range of temperature and for shear strains less than about 0·25 the stress-strain relationship was linear and independent of temperature. The linear relationship of the stress-strain curve persisted for higher strains at 78°K. The annealing at 300°K of crystals deformed at 78°K showed a decrease in electrical resistance accompanied by a phenomenon suggestive of strain ageing. The magnitude of the recoverable resistance was dependent on the strain varying at a faster rate than a linear relationship. A measurable decrease in electrical resistance was not observed for strains less than about 0·30. These results are interpreted according to the theory of dislocations and indicate some modification to the theory of work hardening suggested by Mott. A.

539.374

814. A compression testing instrument for use with pastes. P. MASON. *J. sci. Instrum.*, **30**, 418–21 (*Nov.*, 1953).

An instrument of low frictional resistance is described in which small cylindrical specimens can be compressed by loads up to several kilograms. Loads can be applied at different constant rates or in separate increments and the deformations can be observed using either a dial gauge or an optical lever. Observation of the rate of compression of a bitumen at constant load gives a value for the viscosity substantially in agreement with that found by a concentric cylinder method. The usual method of testing pastes is at a constant rate of loading, a record of specimen height and load being obtained by taking a cine film of the dial gauge and a stop watch by its side. Typical test results for pastes are discussed, concerning the effects of roughness of compression surfaces, of addition of filler to a paste, and of variations in the rate of loading. A.

539.382.2

815. High speed elongation of long test-piece of rubber. S.-I. HYODO. *J. Phys. Soc. Japan*, **8**, 563–5 (*July–Aug.*, 1953).

A method is described for stretching a test-piece 32 cm long and 7 mm^2 in cross-section to rupture at rates of elongation of the order of 100 sec^{-1}. A gunpowder explosion is used to fire a harpoon which pulls out the specimen. The stress-elongation curves are concave towards the stress axis. J. G. OLDROYD

539.385

816. Determination of the surface stress by means of electroplating. H. ŌKUBO. *J. appl. Phys.*, **24**, 1130–3 (*Sept.*, 1953).

This paper presents a new method for the measurement of surface stress. By the use of test pieces plated with copper, the stress is measured by observing the flecks on the surface produced by cyclic stress. The variation in the appearance of flecks which is due to the change of load is very sensitive at a proper load, so an accurate determination of the surface stress is feasible. The stress concentration factor in torsion is obtained experimentally by the method described for circular shafts with a circumferential notch in each. The results are compared with theoretical values, calculated from two different formulae previously derived by the author [*J. appl. Mech.*, **19**, 16 (1952)] and Sonntag respectively. It is confirmed that the experimental results obtained here are in good agreement with those calculated by the author's formula. A.

539.389.3 : 535.551

An optical method of observing stress relaxation in transparent solids. *See Abstr.* 377

539.4.014.3 : 535.55

817. Fundamental relations in photoplasticity. S. E. A. BAYOUMI AND E. K. FRANKL. *Brit. J. appl. Phys.*, **4**, 306–10 (*Oct.*, 1953).

Photoelastic methods of stress analysis have so far been limited to the study of problems of elasticity. The usefulness of such methods has been extended to cover inelastic behaviour by showing that the relative retardation due to loading is determined by the stress and strain components independently of the history of loading. A relation expressing relative retardation as a linear function of stress and strain differences has been derived. This fundamental relation has been verified experimentally for a wide variety of model materials. A fundamental procedure for photoplastic investigations is proposed. This consists of taking two fringe photographs of the same model, one under load, the second immediately after removal of the load. The difference between the fringe counts at corresponding points gives the stress difference which in elastic problems is derived from a single photograph. A.

539.434

818. The design of constant stress cantilevers. A. J. KENNEDY. *J. sci. Instrum.*, **30**, 371–4 (*Oct.*, 1953).

The stress-strain properties of spring cantilevers are examined theoretically in sufficient detail to provide a basis for the design of a constant stress device. The construction and the performance of a particular device are described: this maintains stress constant within ±0·9% for 150% extension, or ±0·5% for 50% extension. The system is robust and simply set up and is economically suitable for multiple testing. A.

539.434

819. Creep tests in inert atmospheres. A. J. FENNER AND G. WILLOUGHBY. *J. sci. Instrum.*, **30**, 406–7 (*Nov.*, 1953).

Apparatus is designed for conducting creep tests of materials which require protection from atmospheric oxidation, using rhomb and mirror extensometers of the kind widely used for high sensitivity creep tests in air. The extensometers are totally enclosed in a chamber which can be evacuated and filled with an inert gas, and the mirrors are viewed through a window. Provision is made for re-setting the mirrors as required during the course of a test. A creep-strain time curve obtained from extensometer readings taken over a period of 250 hr is shown in comparison with curves obtained in similar tests of the same material made with less sensitive apparatus. A.

539.56

820. Room temperature brittleness of chromium. H. L. WAIN AND F. HENDERSON. Letter in *Proc. Phys. Soc.* [*London*] *B*, **66**, 515–17 (*June*, 1953).

Experiments with very pure Cr, in which no metallic impurities could be detected by spectrographic analysis, showed that Cr is not inherently brittle at room temperature, any brittleness being due to impurities. It is suggested that this is produced by the impurities forming "atmospheres" around dislocations so that impure Cr behaves at room temperature like Fe containing C and N does at liquid air temperatures. A. D. LE CLAIRE

539.61

821. Some observations on the adhesion of ice to surfaces. T. BRUNNER. *Z. angew. Math. Phys.*, **3**, *No.* 6, 460–6 (1952) *In German.*

The adhesion of ice grown on different surfaces was investigated by means of a static shearing test. 300 samples all made at similar conditions were tested. The adhesion on clean metal surfaces was found to be about the same magnitude as the shearing stress of ice. A surface-film of silicone grease reduces the adhesion to one half. The apparent shearing stress of ice is also diminished by the same amount. Both effects are attributed to a reduction of the true surface. A.

539.62

822. The influence of load and surface roughness on the friction of rubber-like materials. D. F. DENNY. *Proc. Phys. Soc.* [*London*] *B*, **66**, 721–7 (*Sept.*, 1953).

Experiments with rubber and gelatine under lubricated conditions confirmed that with rubber-like materials the load dependence of friction is consistent with elastic deformation of surface asperities and partial adhesion over the true area of contact. However, the $F \propto W^{2/3}$ relation found by previous investigators obtains only over a limited load range. At very low loads the friction is very nearly proportional to load, whilst at very high loads contact between specimen and track is complete, and the friction remains sensibly constant. When rubber slides on rough tracks there is a large additional friction force unrelated to true contact area. A.

539.62

823. The effect of temperature on the mechanical properties and the friction of plastics. R. F. KING AND D. TABOR. *Proc. Phys. Soc.* [*London*] *B*, **66**, 728–36 (*Sept.*, 1953).

Describes a study of the shear strength S, the indentation hardness or yield pressure P and the coefficient of friction μ of polythene, P.T.F.E., Kel-F and Perspex over a temperature range from $-100°C$ up to $+80°C$. In contrast to metals, the plastics show large changes in their strength properties over the temperature range used, and the confusing effect of surface films on the friction has been eliminated. According to the adhesion theory of friction μ is approximately equal to S/P. In these experiments it is found that μ varies closely with the ratio S/P, but the quantitative agreement is good only with polythene. With Perspex and Kel-F the observed values of μ are consistently larger than S/P, while with P.T.F.E. the values of μ are considerably lower. It is concluded that the adhesion theory can explain the friction behaviour of the plastics examined, the apparent discrepancies being due to the enhanced strength of the junctions under the high localized pressures existing at the interface (Perspex and Kel-F) or to structural factors which give a low intrinsic adhesion at the sliding interface (P.T.F.E.). A.

539.62

824. A simple direct-reading friction meter. V. E. GOUGH. *J. sci. Instrum.*, **30**, 345–9 (*Oct.*, 1953).

The need for a direct-reading friction meter is discussed and the principles of a simple solution to the problem described. The basic mechanism is a platform carried by four identical levers each with a counter weight, and the whole system is in neutral equilibrium. All pivots are of low friction and the levers are arranged so that they are parallel at all angles and in operation all take up a direction parallel to the direction of the resultant reaction between the two surfaces under test, one of which is the platform. The coefficient of friction is the tangent of the angle between the levers and the vertical. Some experimental findings on rubber-like materials are mentioned; these include the importance of the state of the surface. The maximum coefficient is not obtained at rest with rubber-like materials but arises when a slow sliding is taking place. A "squeal" often accompanies this high coefficient. Attention is directed to the need for statistically planned investigations when information is required as a basis for action. An appendix outlines the history of the development of the device. A.

539.62

825. A quantitative study of the wear process. E. RABINOWICZ. *Proc. Phys. Soc.* [*London*] *B*, **66**, 929–36 (*Nov.*, 1953).

In this paper a discussion is presented of the determination of the mass of wear fragments using autoradiographic techniques. The size distribution of copper wear fragments transferred during sliding on mild steel is measured experimentally, and using these data the size distribution of the metallic junctions is calculated. An estimate is presented of the effect on the junctions of an increase of load, and it is shown that the size of the largest junctions, and hence the mass of the largest wear particles, varies much less than does the applied load. In experiments of mild steel sliding on copper carried out to confirm these calculations, the mass of the largest fragments was found to vary approximately as the 0·3 power of the load. A.

539.621

826. Effect of halogenation on the frictional properties of plastics. R. C. BOWERS, W. C. CLINTON AND W. A. ZISMAN. Letter in *J. appl. Phys.*, **24**, 1066–7 (*Aug.*, 1953).

Coefficients of static (μ_s) and kinetic (μ_k) friction for polymers of ethylene and halogenated substituents were measured on a "stick-slip" machine at 25°C for steel on plastic, plastic on steel and plastic on plastic. μ_s and μ_k decrease with fluorine substitution and increase with chlorine substitution. μ_s and μ_k for thin films of plastic on steel were considerably lower which was attributed to a decrease in the area of contact. J. E. CAFFYN

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PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.113 : 537.311.33

827. The atomic heat of germanium below 4°K. P. H. KEESOM AND N. PEARLMAN. *Phys. Rev.*, **91**, 1347–53 (*Sept.* 15, 1953).

This was measured with pure polycrystalline and single crystal ingots, indium and antimony doped single crystal ingots, and pure crushed material. The lattice contribution is in all cases proportional to T^3 and corresponds to a Debye temperature of (362 ± 6)°K, which agrees with the value calculated from elastic constants. From the degree to which this cubic term represents the total measured atomic heat, the estimated upper limit for the ratio of the effective carrier mass to that of free electrons is found to be in the neighbourhood of unity. A.

541.12 : 536.46

828. Combustion rate of artificial graphites from 700°C to 2000°C in air. J. OKADA AND T. IKEGAWA. Letter in *J. appl. Phys.*, **24**, 1249–50 (*Sept.*, 1953).

Cylindrical specimens of artificial graphite 10 mm in diameter and 100 mm long were held horizontally between two artificial graphite electrodes and heated up to 2000°C at atmospheric pressure by passing a current through electrodes and specimens. The results obtained for the rate of combustion up to 1200°C were in agreement with Riddeford's equation [*J. phys. Chem.*, **56**, 745 (1945)], but did not agree for the range 1200°–2000°C. It is suggested that this deviation might depend on the fact that the transition of the type of reaction from "transport" to "chemical" control occurs under the conditions of "transport" control. W. HUGHES

541.121

829. Investigations on silver sulfide. C. WAGNER. *J. chem. Phys.*, **21**, 1819–27 (*Oct.*, 1953).

The variability of the Ag/S ratio in silver sulphide has been studied with the help of electrochemical measurements. Silver sulphide coexisting with metallic silver at 200°C contains a silver excess of $2{\cdot}0\times10^{-3}$ *g*-atom Ag/mole Ag_2S, whereas silver sulphide coexisting with liquid sulphur has very nearly ideal stoichiometric composition. The variability of the Ag/S ratio in β Ag_2S at 160°C is of the order of 3×10^{-5} *g*-atom Ag/mole Ag_2S. The interdiffusion coefficient of silver in Ag_2S at 220°C is about 3×10^3 times greater than the self-diffusion coefficient of silver in Ag_2S. A thermodynamic calculation gives the result that the transformation temperature of Ag_2S coexisting with metallic silver is about 1·7°C lower than the transformation temperature of Ag_2S coexisting with liquid sulphur. A.

541.123.1

830. The solubility diagram and the temperature-composition diagram at atmospheric pressure of the liquid system ozone-oxygen. H. J. SCHUMACHER. Letter in *J. chem. Phys.*, **21**, 1610–11 (*Sept.*, 1953).

New and accurate determinations show that the critical solution temperature is not −158°C as reported by Riesenfeld (1927), but $-180 \pm 0{\cdot}2$°C. The temperature-composition lines for both liquid and vapour phase show strong deviations from those predicted by Raoult's law; up to >80% of O_3 in the liquid phase the vapour contains very little O_3, but at ~85% O_3 content both liquid and vapour have the same composition, at $167{\cdot}8 \pm 1$°K ($-105{\cdot}3 \pm 1$°C). R. C. MURRAY

541.124

831. The formation of black carbon. R. O. GRISDALE. *J. appl. Phys.*, **24**, 1082–91 (*Sept.*, 1953).

Electron microscopic evidence is presented in support of the hypothesis that black carbon resulting from pyrolysis of gaseous hydrocarbons is produced through the intermediate formation of droplets of complex hydrodcarbons. Electron diffraction studies further confirm this hypothesis if, as has been found for particles of carbon blacks, the droplets consist in part of graphitic nuclei arranged with their basal planes tangential to the droplet surface. The carbonization of small solid spherules of highly cross-linked organic polymers is described, and it is shown that the morphology of the carbonization products is wholly analogous to those for pyrolytic carbon and carbon blacks. It is suggested, therefore, that the formation of carbon by the carbonization of solids and by deposition from the gas phase occurs through similar mechanisms and that the two processes are simply two extremes in an infinite series of processes which are all fundamentally alike. A.

541.126

832. Explosions in mixtures of hydrogen, chlorine and nitrogen trichloride. P. G. ASHMORE. *Nature* [*London*] **172**, 449–50 (*Sept.* 5, 1953).

These low-pressure, low-temperature explosions have been studied by comparison with mixtures of nitrogen, chlorine and nitrogen trichloride. In both cases explosions occur below a reproducible upper limit of pressure which appears to be independent of the proportion of NCl_3 and increases with increase of temperature. The parallel behaviour of the two systems suggests that the explosive combination of hydrogen and chlorine is triggered by centres provided by the thermal decomposition of the NCl_3. A branched chain mechanism for the decomposition yielding an upper limit of pressure independent of NCl_3 is proposed. H. H. GREENWOOD

541.127

833. Rate of association of methyl radicals. G. B. KISTIAKOWSKY AND E. K. ROBERTS. *J. chem. Phys.*, **21**, 1637–43 (*Oct.*, 1953).

The recombination rate constant of methyl radicals has been redetermined by the intermittent illumination method as $3{\cdot}7\times10^{13}$ cm^3/mole sec at 165°, after a correction for the concurrent formation of methane. The recombination rate constant of deuterated methyl radicals has been found to have a substantially identical value. The dependence of these second-order rate constants on total pressure was studied over the range of 1 to 10 mm acetone pressure. Both rate

constants were found to decrease identically with pressure. The form of their pressure dependence agrees with deductions from the "third-body" stabilization theory. It is shown that the absolute magnitude of the recombination rate constants, their near-identity and their identical decrease with pressure are all consistent with theoretical predictions, provided the methyl radicals form a loosely bound critical complex, in which they carry out essentially unhindered rotations. Recent literature data on the recombination of methyl radicals are reviewed, and it is shown that they are not in serious disagreement with the present measurements. A.

541.127 : 534.321.9

834. On the use of ultrasonic absorption for the determination of very rapid reaction rates at equilibrium: application to the liquid phase association of carboxylic acids. E. FREEDMAN. *J. chem. Phys.*, **21**, 1784–90 (*Oct.*, 1953).

An equation is derived for the excess acoustic absorption in a liquid system due to the occurrence of a chemical reaction; the method used follows in part that used by Damköhler in the case of gases. It is shown that the gross reaction rate at equilibrium can in general be found once the frequency at which the maximum excess absorption per wavelength occurs has been found, provided thermodynamic data for the reaction are known. The application of this method to the study of the kinetics of very rapid reactions is discussed and the effects of other causes of absorption are considered. As another application of the results obtained the acoustic absorption of acetic and propionic acids is considered. A consistent interpretation of data in the literature is given on the assumption that the excess absorption is due to the perturbation of an equilibrium between monomeric and dimeric molecules. The mole fraction equilibrium constant, K_N, and the heat of reaction for the dimerization are calculated. The values found for acetic acid are $K_N(293°K) = 61{\cdot}97$ and $\Delta H = -6{\cdot}21$ kcal/mole; for propionic acid, $K_N(281{\cdot}2°K) = 3{\cdot}040 \times 10^3$ and $\Delta H = -9{\cdot}33$ kcal/mole. Rate constants and activation energies for the dissociation of the dimers are also calculated. A.

541.127 : 534.321.9

835. Relationships between kinetics and acoustic phenomena in equilibrium systems. M. MANES. *J. chem. Phys.*, **21**, 1791–6 (*Oct.*, 1953).

In a reacting (one-phase, one-reaction) system close to equilibrium, each variable (for example, composition, volume, temperature) approaches its equilibrium value at a rate proportional to its displacement from equilibrium. All the first-order rate constants in a particular state are identical. One can therefore characterize any system at equilibrium by a single relaxation time. When the relaxation of a chemical reaction gives rise to absorption and dispersion of sound, the thermal and dilatational contributions to the relaxational compressibility are necessarily in phase with each other and with the chemical reaction. A known but hitherto limited equation for the propagation of sound has been generalized to combine all such contributions for any system, irrespective of reaction mechanism, so that the propagation of sound may be described in terms of the instantaneous compressibility, the static compressibility and the relaxation time. The relaxation time is a rather simple function of composition, temperature and the rate laws for the forward and reverse reactions; it can be expressed for any postulated pair of rate laws. Therefore, measurement of the relaxation time of a (single) chemical reaction at different equilibrium compositions and temperatures yields kinetic information. The relationships derived here may be applied under certain conditions to acoustic studies of very fast reactions. A.

ELECTROCHEMISTRY 541.13

541.133 : 537.312 : 537.311.33

Theory of a.c. space-charge polarization effects in photoconductors, semiconductors, and electrolytes. *See Abstr.* 457

541.135 : 536.7

836. Thermodynamics of irreversible electrochemical phenomena. S. R. DE GROOT, P. MAZUR and H. A. TOLHOEK; P. H. KEMP. Letters in *Nature* [*London*] **172**, 497–8 (*Sept.* 12, 1953).

De Groot and co-workers reply to Kemp's letter [Abstr. 2012 (1953)], pointing to several errors and inconsistencies, in the first place to a confusion of energy with internal energy in Kemp's equation. The latter's reply concedes this error, but shows that de Groot and co-workers have used a wrong Gibbs equation in their treatment. F. LACHMAN

541.135.5

837. On a mechanism of electrolytic polishing. E. DARMOIS AND I. EPELBOIN. *C.R. Acad. Sci.* [*Paris*] **237**, 501–3 (*Sept.* 7, 1953) *In French.*

Electrolytic polishing of metals in solutions containing ClO_4 ions is explained by the adsorption of these ions on the metallic surface, whereby a layer is formed which creates an electrical field sufficiently intense to cause metallic ions to pass directly into solution. Data are given for Na, Mg, Fe, Ni, Cu, Pb and Hg. Polishing by cathodic pulverization may be similarly explained. H. H. HODGSON

541.135.5

838. Gas content and electrolytic etching behaviour of aluminium. F. J. BURGER AND V. F. G. TULL. Letter in *Nature* [*London*] **172**, 729–30 (*Oct.* 17, 1953).

In an electrolyte of 0·2N sodium chloride etching is more localized if the hydrogen content is high. W. M. LOMER

541.136 : 536.775

839. The correct application of the Gibbs–Helmholtz equation to reversible galvanic cells in which the compositions of some of the phases vary with temperature. R. E. BARIEAU. *J. chem. Phys.*, **21**, 1827–8 (*Oct.*, 1953).

The detailed proof is given that the Gibbs–Helmholtz equation $d\Delta F_{cell}/dT = -\Delta S_{cell}$ is directly applicable to any reversible galvanic cell, regardless of how the compositions of any phases present may vary with the temperature. A.

541.136 : 536.775

840. The thermodynamics of reversible galvanic cells in which the compositions of some of the phases vary with temperature. J. W. STOUT. *J. chem. Phys.*, **21**, 1829–30 (*Oct.*, 1953).

The entropy change calculated from the temperature coefficient of electromotive force of a reversible galvanic cell, in which the compositions of some of the phases vary with temperature, corresponds to a unique correct chemical reaction. The equivalence of methods suggested by Barieau and by Li for determining this correct reaction is shown. The method of Barieau is simpler and more direct and presents the results in a more convenient form. A.

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.14

841. The photolysis of mercury dimethyl in the presence of hydrocarbons. R. E. REBBERT AND E. W. R. STEACIE. *J. chem. Phys.*, **21**, 1723–6 (*Oct.*, 1953).

Mercury dimethyl was photolysed in the presence of various hydrocarbons between 28°C and 251°C. The activation energies in kcal per mole for reactions of the type $CH_3 + RH \rightarrow CH_4 + R$ are: 2-methyl propane-7·4; 2,3-dimethyl butane-6·8; *n*-butane-8·6; cyclohexane-8·3; 2,2-dimethyl propane-10·4; and toluene-7·3, where it is assumed that the activation energy for the reaction $2CH_3 \rightarrow C_2H_6$ is zero. The collision theory steric factors are less than 10^{-3} for all these reactions. The agreement of the above results with those obtained from the photolysis of acetone is noted. A.

541.14 : 539.155.2

The photochemical separation of isotopes. *See Abstr.* 703

541.15

842. Effect of gamma radiation on certain rubbers and plastics. J. W. RYAN. *Nucleonics*, **11**, 13–15 (*Aug.*, 1953).

A number of plastics and rubbers were exposed to an average γ-ray flux of 10^{11} photons/cm^2/sec, from fission products, for a period of 6 months. An examination of the mechanical properties revealed a decrease in flow characteristics, the elastic modulus increasing and plastic flow decreasing. Gas evolution was observed. It is suggested that the irradiation produces cross linkages. L. R. SHEPHERD

541.15

843. X-ray measurements of radiation damage in black phosphorus. D. L. CHIPMAN, B. E. WARREN AND G. J. DIENES. Letter in *J. appl. Phys.*, **24**, 1251 (*Sept.*, 1953).

Orthorhombic black P, irradiated in the Brookhaven pile for one month at about 50°C (no other conditions given) shows an expansion of 0·03% along the *c*-axis, as measured by X-ray diffraction. The reflections show a slight broadening. New reflections appear which are not fully explained but suggest that the black P may be reverting to red. J. THEWLIS

541.15 : 539.172.4

844. Szilard and Chalmers effect by irradiation of hexavalent chromium in an atomic pile. B. OTTAR. Letter in *Nature* [*London*] **172**, 362 (*Aug.* 22, 1953).

Trivalent Cr^{51} was found after irradiation of various compounds. Percentages of trivalent activity were: for CrO_3 solid, 13 ± 2; 6M chromic acid, 6 ± 1; $KCrO_4$ solid, 14 ± 3; and $K_2Cr_2O_7$ solid, $1{\cdot}5 \pm 1$. F. R. HOLT

DISPERSIONS . COLLOIDS . ADSORPTION 541.18

541.182.2

845. The particle size distribution in fog produced by ultrasonic radiation. T. K. MCCUBBIN, JR. Letter in *J. Acoust. Soc. Amer.*, **25**, 1013–14 (*Sept.*, 1953).

The author describes fog produced by 2·4 Mc/s sound generated in water and focused on the upper surface. With soap in the water no fog appears. Fog particle diameters, determined by microscope, are grouped around 4 to 5 microns. A.

541.182.3

846. Behaviour of aerosols in acoustic and turbulent fields. E. G. RICHARDSON. *Acustica*, **2**, *No.* 4, 141–7 (1952).

It is well known that the particles in a mist or smoke are brought into collision with each other or with neighbouring surfaces by the action of sound waves. In so far as a turbulent regime may be regarded as the superposition of periodic velocity fluctuations on a steady flow, a similar action may be expected on an aerosol subjected to turbulence. This paper describes experiments concerning the effects of acoustic and turbulent fields on the rate of coagulation of aerosols. A.

541.183

847. Effects of electronic charge transfer between adsorbate and solid on chemisorption and catalysis. P. B. WEISZ. *J. chem. Phys.*, **21**, 1531–8 (*Sept.*, 1953).

When chemisorption on a semi-conductive solid is accompanied by electronic charge transfer between adsorbate and solid, an electronic boundary layer analogous to that in rectifying junctions may develop and polarization of charges in the solid may result. These phenomena may limit or control the chemisorption characteristics. The boundary layer theory developed for electrical contacts and elementary considerations concerning the effect of the polarization potential are applied to derive the form of relationships for the extent, heats and rates of chemisorption and some consequences with respect to catalysis. An attempt is made to illustrate the detailed physical processes in order to examine the meaning of "heterogeneity" and "active centres" in cases of this type of chemisorption. A.

CHEMICAL STRUCTURE 541.2/.6

541.634 : 535.343.32–15

848. New infrared investigations in the *cis-trans* isomerism of *ortho*-halogenphenols. G. Rossmy, W. Lüttke and R. Mecke. Letter in *J. chem. Phys.*, **21**, 1606–7 (*Sept.*, 1953).

The first OH vibration overtone of *o*-chlorophenol was previously found to show two lines of very different intensity. It had been suggested that these were originating from the *cis*- and *trans*-forms of the molecule. In order to check this the fundamental OH band, the higher overtones and the analogous bands of other *o*-halogenphenols were investigated. The infrared spectra were taken with well purified samples and compared with Raman spectra, which gave good agreement. Quantitatively previous results did not agree well, although the general conclusions were confirmed. The effect of temperature on the bands was also studied: the differences in energy and free energy between both configurations were found to be 3·2 and 2·8 kcal/mole respectively. In CCl_4 solution the free energy difference was only 1·4 kcal/mole (2·1 kcal/mole for the bromine compound); the *trans* configuration seemed to be stabilized by the solvent. A. J. TAYLOR

CHEMICAL PROCESSES 542.9

542.9

849. Investigation of pyrolyses of benzyl benzoate, acetate and formate. M. Szwarc and J. W. Taylor. *J. chem. Phys.*, **21**, 1746–9 (*Oct.*, 1953).

The pyrolysis of benzyl benzoate, benzyl acetate and benzyl formate was studied by means of "toluene carrier gas" technique. It has been shown that benzyl-benzoate decomposes according to the equation $Ph{\cdot}CH_2{\cdot}O{\cdot}CO{\cdot}Ph \rightarrow Ph{\cdot}CH_2{\cdot} + Ph{\cdot}COO$. The $Ph{\cdot}CH_2{-}O{\cdot}CO{\cdot}Ph$ bond dissociation energies have been estimated as less than 69 kcal/mole. Decompositions of benzyl acetate and of benzyl formate are more complicated; the dissociation into radicals is accompanied by some decompositions into smaller molecules. The data enable one to determine the relative rates of reactions, $Ph{\cdot} + C_6H_5{\cdot}CH_3 \rightarrow Ph{\cdot}H + C_6H_5{\cdot}CH_2{\cdot}$ and $Ph{\cdot} + C_6H_5{\cdot}CH_2{\cdot}O{\cdot}CO{\cdot}C_6H_5 \rightarrow Ph{\cdot}H_4 + C_6H_5{\cdot}CH{\cdot}O{\cdot}CO{\cdot}C_6H_5{\cdot}$. The latter reaction appears to be twice as rapid as the former. A.

CHEMICAL ANALYSIS 543/545

545.82 : 535.33.07

A new approach to direct reading spectrochemical analysis. *See Abstr.* 236

545.82 : 535.33.072

Quantitative spectrochemical analysis with the aid of a slitless spectrograph. *See Abstr.* 249

545.827

850. Detection of the HO_2 radical by mass spectrometry. S. N. Foner and R. L. Hudson. Letter in *J. chem. Phys.*, **21**, 1608–9 (*Sept.*, 1953).

The HO_2 radical has been detected in the reaction between hydrogen atoms and oxygen molecules in the gas phase by means of the mass spectrometer. Oxygen mixed with an inert gas, which serves to stabilize the gas flow and to deactivate molecules is injected into the centre of a stream of atomic hydrogen. The products enter a special mass spectrometer which uses a molecular beam sampling system. A. J. MEE

CRYSTALLOGRAPHY 548

548.0 : 535.412

The cleavage of topaz. *See Abstr.* 356

548.0 : 536.413

851. Thermal expansion of crystals. V. Hæmatite. S. S. Sharma. *Proc. Indian Acad. Sci. A*, **32**, 285–91 (*Nov.*, 1950).

For Pt IV, see Abstr. 3189 (1951).

548.0 : 548.7

852. On the morphology and structure of diamond. E. Jumpertz, H. Kircher and W. Kleber. Note in *Naturwissenschaften*, **40**, *No.* 15, 409–10 (1953) *In German.*

A conclusion is drawn from the available literature data that the symmetry of diamond is very probably a hexakistetrahedral (not hexakisoctahedral) one. Two kind of C atoms, slightly differing from one another in electron-density distribution, are present in the diamond lattice. F. LACHMAN

548.0 : 535.81

853. The physical properties of crystalline cesium iodide. S. S. Ballard, L. S. Combes and K. A. McCarthy. *J. Opt. Soc. Amer.*, **43**, 975–6 (*Nov.*, 1953).

Data given indicate that this new infrared-transmitting crystal compares favourably with caesium bromide and thallium bromide–iodide. A.

548.0 : 539.32

Elastic properties of polycrystalline aggregates. *See Abstr.* 809

548.5

854. Evidence for the movement of dislocations obtained from spiral pits. S. Amelinckx and E. Votava. Note in *Naturwissenschaften*, **40**, *No.* 10, 290 (1953).

Photographs of spiral pits [see Abstr. 8046 (1953)] in salol and thymol crystals grown while floating on solution, show that a dislocation line has moved during the growth. A. R. STOKES

548.5

855. Transition layers between crystalline and monomolecular regions in very thin plates of polymolecular compounds. H. DEVAUX. *C.R. Acad. Sci.* [*Paris*] **237**, 287–91 (*July* 27, 1953) *In French.*

If a drop of $CuSO_4$ or some other salt solution is brought on to mercury, it extends immediately though it does not cover all the available surface. The outer region of the $CuSO_4$ layer is monomolecular, in the centre polymolecular plates are formed which crystallize, and in between there is a polymolecular zone. At the contact with the crystalline zone, non-crystalline disks are formed solely under the influence of the crystals, as no nuclei of other matter affect the formation. If the crystals are removed, the fluid molecules agglomerate in the regions of greatest thickness, the lowest possible thickness being of the order of twice the molecular diameter. A. J. TAYLOR

548.52

856. Relation between Frank spirals and spiral pits in crystals. S. AMELINCKX AND E. VOTAVA. Letter in *Nature* [*London*] **172**, 538 (*Sept.* 19, 1953).

Thin crystals of potassium ferrocyanide, growing while floating on an aqueous solution of the substance, were examined in monochromatic light. The observed polygonized growth spirals and the fringe systems centred on them, some of which are illustrated, are stated to give strong evidence that Frank spirals [Abstr. 1343 (1950)] and spiral pits [Abstr. 2808 (1953)] have a common origin in a dislocation.

S. WEINTROUB

MOLECULAR AND X-RAY CRYSTALLOGRAPHY 548.7

548.7

857. On the characteristic vibrations of linear lattices. K. S. VISWANATHAN. *Proc. Indian Acad. Sci. A*, **35**, 265–76 (*May*, 1952).

The nature of wave propagation in a linear lattice consisting of p particles in its unit cell is studied and it is shown that the group velocity of the waves corresponding to each of the $(2p–1)$ characteristic frequencies of the lattice is identically equal to zero. It is further proved that the state of movements of the particles resulting from an initial disturbance localized in a finite region of the lattice tends asymptotically to a superposition of the $(2p–1)$ characteristic vibrations of the lattice. In $(p–1)$ modes of these vibrations, equivalent particles in successive cells vibrate with the same phases and amplitudes, while in the remaining p normal modes, vibration occurs with equivalent particles moving alternately with opposite phases. These results form a one-dimensional analogue of the general theory of vibrations of crystal lattices formulated by Raman and are generalizations of the results corresponding to the cases $p = 1$ and $p = 2$ which were first obtained respectively by Hamilton and by Nagendra Nath and Roy [Abstr. 4905 (1949)]. In view of the decay of the amplitudes of vibrations of the particles with time, these results hold good for a finite lattice also, provided its length is sufficiently large and the domain of initial disturbance is far from its ends. A.

548.7

858. The characteristic vibrations of a rectangular lattice. K. S. VISWANATHAN. *Proc. Indian Acad. Sci. A*, **36**, 306–14 (*Oct.*, 1952).

For a rectangular lattice with one particle in each unit cell, it is shown that the group velocity of the waves vanishes for the six characteristic frequencies and that the state of movements of the particles arising out of an initial disturbance tends to a superposition of these six characteristic vibrations of the lattice. These six frequencies would reduce to three for a square lattice on account of its symmetry; in both these cases, however, the amplitudes of vibrations of the particles vary inversely as the time elapsed from the instant of the initial disturbance. The physical interpretation of these results and their applicability to the case of a finite lattice are discussed.

A.

548.7 : 536.631

The lattice vibration specific heat of graphite. *See Abstr.* 417

548.7 : 536.631

Computation of mean Debye temperature of cubic crystals from elastic constants. *See Abstr.* 418

548.7 : 536.7

Thermodynamics of sodium chloride lattice. I. Equation of state. II. Use of thermal expansion data for drawing isotherms. *See Abstr.* 422–3

548.7 : 538.245

A proposed structure for certain domain configurations on a single crystal of nickel. *See Abstr.* 611

548.7

859. The characteristic vibrations of crystal lattices. I. K. S. VISWANATHAN. *Proc. Indian Acad. Sci. A*, **37**, 424–34 (*March*, 1953).

It is shown that the structure of a crystal as a three-dimensional repetitive pattern of lattice cells of atoms leads automatically to the result that the group velocity of the waves associated with the $(24p–3)$ characteristic frequencies should be equal to zero, and hence that oscillations having these frequencies are in the nature of stationary normal modes of vibration of the crystal lattice. It is further proved that any arbitrary initial disturbance asymptotically settles into a superposition of these $(24p–3)$ characteristic vibrations which were first predicted by Raman [Abstr. 2989 (1948)], and that their amplitudes of vibration vary inversely as $t^{3/2}$ and further, that the energies associated with other frequencies of vibration are of negligible magnitude. A.

548.7

860. The characteristic vibrations of crystal lattices. II. K. S. VISWANATHAN. *Proc. Indian Acad. Sci. A*, **37**, 435–40 (*March*, 1953).

It is shown that the wave and group velocities of the elastic waves are identical. An initial disturbance consisting of a translation of a supercell excites asymptotically the $(3p–3)$ characteristic vibrations only, the amplitudes of the remaining $21p$ modes being zero to a first order of approximation. A translation of a single unit cell results in exciting all

the $(24p-3)$ modes of vibrations of the crystal. The question of reduction of the asymptotic expression for the displacements of the atoms about their mean positions to its simplest form, when degeneracies are present in these vibrations, is also considered. A.

548.7

861. Vibrations in a simple cubic lattice. I. H. B. Rosenstock and G. F. Newell. Letter in *J. chem. Phys.*, **21**, 1607–8 (*Sept.*, 1953).

A monatomic lattice was considered, non-central forces between nearest neighbours only being taken into account. The secular equation gave values for the frequencies. The frequency distribution curve was evaluated. This function had singularities at six points only; the behaviour in the neighbourhood of these points could be found by expansion. The general outlines of the curve were found for various values of the force constants. These are sketched; one example is calculated. A. J. TAYLOR

548.7

862. Vibrations of a simple cubic lattice. II. H. B. Rosenstock and H. M. Rosenstock. Letter in *J. chem. Phys.*, **21**, 1608 (*Sept.*, 1953).

Here the calculations were based on the assumptions of central forces in the same monatomic cubic lattice, but interactions were taken into account as far as third nearest neighbours. The secular determinant gave three solutions for the frequencies, but for most values of the force constant ratios these frequencies became irrational and complicated. Apart from trivial cases only one rational frequency branch could be found and of this branch the distribution curve was evaluated. It is continuous throughout, with square root behaviour at each end-point; most frequencies lie in a small region $(0{\cdot}6 < \omega^2 < 0{\cdot}8)$. Near its four singular points it shows square root behaviour at one side and is linear at the other.

A. J. TAYLOR

548.7

863. Variable activation energy and the motion of the lattice defects. G. J. Dienes. Letter in *Phys. Rev.*, **91**, 1283 (*Sept.* 1, 1953).

The activation energy E for the annealing-out of lattice defects may depend, because of the strains they introduce into the lattice, upon the number n of defects present. A discussion is given of the type of annealing curve (n plotted against time of anneal at fixed temperature) that is obtained when E is assumed to decrease linearly with increasing n. A. D. LE CLAIRE

548.7

864. Edge dislocations in inhomogeneous media. A. K. Head. *Proc. Phys. Soc.* [*London*] *B*, **66**, 793–801 (*Sept.*, 1953).

A general method is given, by which problems of elastic plane strain in a bimetallic medium can be reduced to standard problems of potential theory. A bimetallic medium is one where the elastic constants are different on either side of a plane. The boundary between the two semi-infinite solids can be either a complete weld, or it can transmit direct stress but not shear stresses. A special case is a semi-infinite solid with a free surface. Specific examples considered are (i) an edge dislocation in a semi-infinite solid with a free surface, (ii) an edge dislocation in a bimetallic solid for both types of boundary. In neither case can the stress field be given a simple interpretation in terms of images. However, the stress tending to move the dislocation is the same as that of a dislocation of suitable strength at the image point. A.

548.7 : 536.413.2

865. Effect of distribution of lattice defects within crystals on linear expansion and X-ray lattice constant. P. H. Miller, Jr and B. R. Russell. Letter in *J. appl. Phys.*, **24**, 1248–9 (*Sept.*, 1953).

See Abstr. 535 (1953). It is now acknowledged that the change of X-ray lattice constant may be larger or smaller than the change in linear dimensions according to whether Frenkel defects are concentrated near the centre or near the surface of the crystal.

A. R. STOKES

548.7 : 536.413.2

866. Geometrical and apparent X-ray expansions of a crystal containing lattice defects. J. D. Eshelby. Letter in *J. appl. Phys.*, **24**, 1249 (*Sept.*, 1953).

See previous abstract. The effect of a completely random distribution of defects in a spherical crystal is calculated, and the X-ray and macroscopic expansions are shown to be equal. A. R. STOKES

548.7

867. Perfect crystals of zinc sulfide. W. W. Piper and W. L. Roth. Letter in *Phys. Rev.*, **92**, 503 (*Oct.* 15, 1953).

Hexagonal ZnS crystals, 5×10^{-3} cm diameter and several mm long, grown by sublimation in a H atmosphere, appear free of dislocations and stacking faults; X-ray photographs showed no diffuse streaking. The needles are flexible, elastic strains up to $1{\cdot}5\%$ have been induced, Young's modulus $= 7\times10^{11}$ dynes/cm^2. Photocurrent decay in these crystals was at least ten times faster than the usual decay time.

J. FRANKS

548.7

868. Stable dislocations in the common crystal lattices. F. C. Frank and J. F. Nicholas. *Phil. Mag.*, **44**, 1213–35 (*Nov.*, 1953).

On the assumption that the energy per unit length of a dislocation line is proportional to the square of the Burgers vector, the stability of dislocations in simple cubic, face-centred cubic, diamond, hexagonal close-packed and body-centred cubic lattices is discussed. It is shown that in each of these lattices, there is only a finite number of Burgers vectors which correspond to stable perfect dislocations; these vectors are enumerated. Imperfect dislocations are discussed for those lattices in which they can occur and the finite sets of Burgers vectors corresponding to isolated stable imperfect dislocations are found. Stable extended dislocations, consisting of arrays of imperfect dislocations separated by areas of translation-twin surfaces, are discussed, but there is no limit to the number of these that is geometrically possible. A.

548.7

869. On the electronic structures of the *M*-centers in alkali-halide crystals. T. Inui, Y. Uemura and Y. Toyozawa. *Progr. theor. Phys.*, **8**, 355–62 (*Sept.*, 1952).

The electronic energy levels of the *M*-centres in coloured LiCl and NaCl crystals are calculated by

LCAO method, assuming Seitz's model. The ground state and the first excited state (optically permitted) are shown to belong to A_1 and B_1 symmetry, respectively, the wavelengths of the optical transition between them being in comparatively good agreement with the observed M-absorption peaks. A.

548.7

870. The band width [W] of the F band in KBr at 78°K. I. L. Mador, J. J. Markham and R. T. Platt, Jr. Letter in *Phys. Rev.*, **91**, 1277 (*Sept.* 1, 1953).

Four X-ray coloured and one additively coloured single crystals were measured with a probable error $< 0{\cdot}001$ eV. W ranged from 0·196–0·208 eV and is not related to concentration or susceptibility to bleaching of the colour-centres. J. E. CAFFYN

548.7

871. Bleaching of CaF_2 crystals colored by X-rays. A. Smakula. Letter in *Phys. Rev.*, **91**, 1570 (*Sept.* 15, 1953).

548.7 : 541.15

872. On the presence of free chlorine in sodium chloride crystals containing color centers and color center precursors. M. Hacskaylo, D. Otterson and P. Schwed. *J. chem. Phys.*, **21**, 1434–5 (*Sept.*, 1953).

Measurements were carried out of the free chlorine content of NaCl crystals subjected to electrolysis before and after exposure to X-rays, as well as the free chlorine content of normal NaCl crystals after irradiation. It has been found that crystals which have not been irradiated contain no free chlorine, whereas those exposed to X-rays contain between 0·1 and 0·6 free chlorine atom per vacancy pair. A.

548.7

873. Note on some regularities of the absorption band maxima of colored alkali metal halides. A. Glasner and F. C. Tompkins. *J. chem. Phys.*, **21**, 1817–18 (*Oct.*, 1953).

The various relationships which exist between the absorption band maxima of coloured alkali metal halides have been noted, and some simple empirical rules have been proposed for calculating certain crystal parameters from the position of these maxima. A.

548.73/.74 : 539.26/.27

X-ray and electron investigation of materials. *See Abstr.* 804–6

548.732

874. X-ray anti-reflections in crystals. G. N. Ramachandran and G. Kartha. *Proc. Indian Acad. Sci. A*, **35**, 145–58 (*March*, 1952).

"Anti-reflection" is used to describe the phenomenon where the intensity of the transmitted beam may exhibit a peak larger than the background when a Bragg reflection occurs in an absorbing crystal. The theory is based on the dynamical theory of Ewald and Laue. The effect is due to a decrease in the effective absorption coefficient of the crystal near the Bragg reflection, and to the consequent increase in the transmitted intensity predominating over the loss of energy by reflection. The anti-reflection peak becomes more prominent, the greater the thickness of the crystal. The results of the theory are found to be in accord with the previous observations of Borrmann, and Campbell [Abstr. 9821 (1951)]. The theory further predicts that the peaks in the reflected and transmitted beams would not be coincident and this requires further verification. A.

548.733

875. The use of Geiger and proportional counters in X-ray diffraction studies. U. W. Arndt. *Atomics [London]* **4**, 217–26 (*Sept.*, 1953).

A general description of the techniques, and including some discussion of longitudinal variations of sensitivity in Geiger counters, the efficiency of counting X-ray quanta, stability and counting errors. Typical results (X-ray spectra, etc.) are shown. 28 references. J. D. CRAGGS

548.733

876. Some observations on the use of precision X-ray Geiger counter spectrometers. G. K. Williamson and R. E. Smallman. Note in *J. sci. Instrum.*, **30**, 341 (*Sept.*, 1953).

The authors comment on a paper by Coyle *et al.* [Abstr. 5207 (1953)]. In their experience halogen and organic-vapour quenched counters give good day-to-day reproducibility if the dead time imposed by the quenching circuit exceeds the total recovery time of the counter. Beam instability usually attributed to focal spot shift largely disappears if this counting circuit condition is correct. A method of monitoring the beam by using radiation normally stopped by the lead slit is described. L. E. MUSSELL

548.733

877. A low-temperature Weissenberg X-ray camera. H. Steinfink, J. Ladell, B. Post and I. Fankuchen. Note in *Rev. sci. Instrum.*, **24**, 882–3 (*Sept.*, 1953).

The specimen is cooled by a stream of cold air. As the tube carrying this air would interfere with the loading of a normal cylindrical camera, the camera and layer screen are both made in two halves, which can be inserted separately. A. R. STOKES

548.733

878. An automatic X-ray reflection specimen holder for the quantitative determination of preferred orientation. W. P. Chernock, M. H. Mueller, H. R. Fish and P. A. Beck. *Rev. sci. Instrum.*, **24**, 925–8 (*Oct.*, 1953).

A reflection specimen holder has been developed, which has several new features. A removable jig, which fits into the inner ring, is used for the rapid alignment of the specimen. Two different specimen scanning devices are described, which allow the primary beam to cover successively a large number of grains in the specimen surface while the diffracted intensity is being measured. Since many such time consuming measurements are required for an accurate pole figure, the operation of the instrument and the recording of the data have been made automatic. A.

548.733

879. An integrating photometer for X-ray intensity measurements. E. Alexander, B. S. Fraenkel, A. Many and I. T. Steinberger. *Rev. sci. Instrum.*, **24**, 955–60 (*Oct.*, 1953).

X-ray diffraction spots on films vary in area and are uneven in density. An instrument is described,

which, after calibration against a standard intensity scale imprinted on the film, scans the spot by a light ray, and transforms transmitted light pulses into linear functions of intensity by electronic means. A figure, proportional to the intensity of the spot, is obtained on a mechanical counter. The integrating process is fully automatic, and measurement of one spot takes about a minute. Reproducibility depends on the relative intensity of the measured spot and can be raised up to 1%. A.

548.733

880. A novel X-ray heating camera. S. S. MARSDEN AND N. R. SANJANA. *J. sci. Instrum.*, **30**, 427–9 (*Nov.*, 1953).

An inexpensive, X-ray heating camera has been designed for samples containing a volatile component. Both heating of the sample and the determination of temperature are accomplished by the condensation of vapours principle. The camera has been used successfully up to 250°C. A.

548.733

881. On monitoring a Geiger-counter spectrometer beam. E. GILLAM AND D. G. COLE. *J. sci. Instrum.*, **30**, 429–30 (*Nov.*, 1953).

Tests on three different ways of monitoring a Geiger-counter spectrometer beam with a second Geiger counter show that the most suitable method appears to be a single-window single-beam system, in which an aluminium foil is placed in the path of the beam and diffracts a fraction of the intensity into the monitoring counter. This system has the advantage of using only one window of the X-ray tube although its variances are not noticeably smaller than a two-window system. It also does not appear to drift over long periods of time. A general difficulty in the monitoring of such beams by this method is discussed. A.

548.734

882. A nomogram for evaluating the temperature factor. H. J. GRENVILLE-WELLS. *Acta cryst.*, **6**, 665–6 (*July*, 1953).

548.734

883. The direct use of three-dimensional X-ray data in crystal-structure determination. P. A. KENYON AND C. A. TAYLOR. Note in *Acta cryst.*, **6**, 745–6 (*Sept.*, 1953).

The X-ray diffraction data are displayed three-dimensionally on a series of parallel glass plates. The main features of a structure may sometimes be obtained directly from this display, e.g. it is shown how the orientations of naphthalene molecules were found. A. R. STOKES

548.734

884. Charts for obtaining geometrical corrections directly from anti-equi-inclination photographs. G. KARTHA. Note in *Rev. sci. Instrum.*, **24**, 871 (*Sept.*, 1953).

Gives a method for preparing charts for the Lorentz and polarization corrections in anti-equi-inclination Weissenberg photographs. Such a chart contains curves of constant correction, the correction being plotted against the anti-equi-inclination angle used in recording the photograph. An example is given. J. THEWLIS

548.734

885. The mechanical transformation of Weissenberg pictures to undistorted theta lattices. D. MCLACHLAN, JR AND R. H. WOOLLEY. Note in *Rev. sci. Instrum.*, **24**, 872–3 (*Sept.*, 1953).

Describes a device whereby a Weissenberg photograph is optically projected to give a nearly undistorted reciprocal lattice picture. This has the advantage, over direct methods of photographing the reciprocal lattice, that the Weissenberg camera covers nearly the whole range of θ values. A. R. STOKES

548.734

886. Determination of the diameter of circles in the precision determination of lattice constants. R. F. RAEUCHLE. Note in *Rev. sci. Instrum.*, **24**, 875 (*Sept.*, 1953).

A circle is fitted by the method of least squares to the measured co-ordinates of a number of points: its radius is shown to be the arithmetic mean of the distances of the points from an estimated centre. A. R. STOKES

548.734.8

887. The measurement and correction of intensities from single-crystal X-ray photographs: correction. G. KAAN AND W. F. COLE. *Acta cryst.*, **6**, 666 (*July*, 1953).—See Abstr. 3580 (1949).

548.735.4

888. Remarks on the technique of least squares refinement in X-ray structure analysis. H. SØRUM. *K. Norske Vidensk. Selsk. Forhandl.*, **25**, *No.* 21, 107–11 (1952).

This gives considerable reduction of the calculation work, by taking a simplified form of the normal equations. It has been tested on anorthite and on dimethanesulphonyl disulphide. C. TURNER

548.735.46

889. The use of the "sharpened" Patterson in the resolution of structures. V. CAGLIOTI AND A. ADDAMIANO. *Ricerca sci.*, **23**, 1369–75 (*Aug.*, 1953) *In Italian.*

Some properties of the "sharpened" Patterson series are discussed. The *AA* show that, when the number of terms used in calculating the series is large enough, the interpretation of the sharpened Pattersons is easier than that of the usual Patterson functions, calculated with the same number of terms. A.

548.735.46

890. A contribution to the vector-algebraic method for the interpretation of the Patterson synthesis. A. BEZJAK. Note in *Acta cryst.*, **6**, 748–9 (*Sept.*, 1953).

See Abstr. 9191 (1952). A further method of obtaining a centro-symmetrical structure from the positions of Patterson peaks is given. A. R. STOKES

548.736.3

891. Antiparallel dipole arrangement in tungsten trioxide. R. UEDA AND J. KOBAYASHI. Letter in *Phys. Rev.*, **91**, 1565 (*Sept.* 15, 1953).

A detailed crystal structure analysis of WO_3 has been carried out from a study of its Patterson function. The space group is $P2_1/a$ and lattice constants and interatomic distances are given. The dipole arrangement is similar to that of $NaNbO_3$ in which the dipoles parallel to the x-direction are arranged in alternate senses while the ones perpendicular to it are

in the same sense. These dipole orientations lead to anti-ferroelectric properties. A. E. DE BARR

548.736.4

892. The structure of β(AlCrSi). K. ROBINSON. *Acta cryst.*, **6**, 667 (*July*, 1953).

548.736.4

893. Crystal chemical studies of cobalt carbonyls. I. Cobalt tetracarbonyl. L. CAVALCA AND I. W. BASSI. *Ricerca sci.*, **23**, 1377–88 (*Aug.*, 1953) *In Italian.*

Cobalt–tetracarbonyl crystals are monoclinic [the most probable space groups are $C_{2h}(2)$ and $C_2(2)$], with the following unit cell dimensions: $a = 11{\cdot}26 \pm 0{\cdot}05$ Å; $b = 15{\cdot}45 \pm 0{\cdot}01$ Å; $c = 6{\cdot}56 \pm 0{\cdot}01$ Å; $\beta = 90°22' \pm 14'$; $Z = 4$; $D_m \sim 1{\cdot}87$; $D_x = 1{\cdot}99$. The interatomic distance Co–Co $= 2{\cdot}53 \pm 0{\cdot}04$ Å has been determined by means of the two-dimensional Patterson synthesis on (001); the presence of carbonyl bridges between the two metallic atoms has been besides observed. Constitution formulae, proposed by Ewens considering the magnetic properties and the chemical analogy between $[Co(Co)_4]_2$ and $Fe_2(CO)_9$, has been, in this way, experimentally confirmed. A.

548.737

894. Extra Laue reflections of tetraphenylethylene crystal. M. N. DUTT. Letter in *J. chem. Phys.*, **21**, 1609–10 (*Sept.*, 1953).

This substance was crystallized from ethyl alcohol solution by adding benzene. The crystals are monoclinic with $a = 11{\cdot}36$, $b = 9{\cdot}37$, $c = 10{\cdot}10$ Å, $\beta = 68°20'$. Density $= 1{\cdot}057$ g.cm^{-3}. One molecule per unit cell. Space group $P2/m$. Extra Laue spots of thermal origin are observed for certain planes and some of these change their position when the radiation is changed from Ni$K\alpha$ to Co$K\alpha$. J. IBALL

548.737

895. Structure of meta-aminophenol. M. N. DUTT. Letter in *Nature* [*London*] **172**, 498 (*Sept.* 12, 1953).

Orthorhombic, $a = 6{\cdot}31$, $b = 11{\cdot}12$, $c = 8{\cdot}60$ Å, probable space-group *Pma*. Refractive indices along *a*-, *b*- and *c*-axes are $\gamma = 1{\cdot}638$, $\beta = 1{\cdot}625$, $\alpha = 1{\cdot}505$. The plane of the benzene ring therefore lies close to the α and β directions. A. R. STOKES

548.737 : 535.343–15

896. Crystal structure of silanols and their infrared spectra. M. KAKUDO, P. N. KASAI AND T. WATASE. Letter in *J. chem. Phys.*, **21**, 1894–5 (*Oct.*, 1953).

Crystallographic data are given for diallylsilanediol, bis-(dimethylhydroxysilyl)-methane, and tetramethyl-disiloxane-diol-1, 3. They all form molecular chains, joined by –OH-groups, showing hydrogen bonds of type 1. It is suggested that this kind of structure is a property of the hydroxyl groups in silanols, accounting for their physico-chemical behaviour. C. TURNER

548.74

897. Neutron-diffraction study of the structure of the *A*-form of the rare earth sesquioxides. W. C. KOEHLER AND E. O. WOLLAN. Note in *Acta cryst.*, **6**, 741–2 (*Sept.*, 1953).

Neutron diffraction data show that the accepted structure of the hexagonal form of the rare earth sesquioxides is valid for La_2O_3, Pr_2O_3 and Nd_2O_3, the positions of the O atoms, inferred indirectly from X-ray measurements, being confirmed. The coherent magnetic scattering, if any, contributes less than 5% to the observed intensities of La_2O_3. J. THEWLIS

548.74

898. Structure of selenium tetrafluoride. F. LACHMAN. Letter in *Nature* [*London*] **172**, 499 (*Sept.* 12, 1953).

Gives two equivalent equations relating the valency angles in the distorted tetrahedron assumed for SeF_4 by Bowen [Abstr. 8803 (1953)], and points out that the secants of angles determined experimentally are expressed by small negative integers. F. LACHMAN

GEOPHYSICS 55

550.311 : 550.42 : 550.93

899. Effects of a primeval endowment of U^{236}. D. B. ROSENBLATT. *Phys. Rev.*, **91**, 1474–5 (*Sept.* 15, 1953).

The effects of a primeval endowment of U^{236} upon theories pertaining to the evolution of the elements, the thermal history of the earth and geochronology are considered. It is shown that the present thorium to uranium ratio, early volcanism on the earth and on the moon, as well as corrections to the dating of rocks and meteorites may be related to an initial abundance of the isotope, if certain assumptions are made. A.

550.834

900. Seismic model study. E. T. HOWES, L. H. TEJADA-FLORES AND L. RANDOLPH. *J. Acoust. Soc. Amer.*, **25**, 915–21 (*Sept.*, 1953).

A method has been developed for studying seismic sound pulses in reduced scale models which simulate geophysical seismic exploration methods. Use is made of a tank of water for transmission of the acoustic wave from a source to a faulted limestone stratum and return to a pressure sensitive receiver. Results obtained demonstrating the geometric aspects of the propagation, reflection, refraction and diffraction of sound pulses are described and illustrated on accompanying plates. A.

550.93 : 539.16

901. Determination of the absolute age of a pitchblende from the lode-bearing layer of Crouzille, in the granulitic massif of St. Sylvestre, north of Limoges. A. DEMAY. *C.R. Acad. Sci.* [*Paris*] **237**, 48–50 (*July* 6, 1953) *In French.*

The age was determined from 3 measurements: the relative content of U, Th and Pb of radioactive origin, the ratio Pb^{207}/U, and the ratio Pb^{207}/Pb^{206}. The most probable true age is 147×10^6 yrs.

A. O. STANESBY

550.93 : 539.16.08

902. Yale natural radiocarbon measurements. I. Pyramid Valley, New Zealand and its problems. M. BLAU, E. S. DEEVEY, JR AND M. S. GROSS. *Science*, **118**, 1–6 (*July* 3, 1953).

Describes the progress made in the Geochrono-

metric Laboratory on the development of a routine method of radiocarbon dating. Blank determinations and the radioactive carbon counts for modern wood and shell have been determined: a theory is advanced for differences in the behaviour of different shells, and it is suggested that present practice of assuming a higher activity for shells than wood is in need of review, and it is suggested that the figure for modern wood should be used for all cases until better data is available. It is suggested that an error of 10% is probable and that 25% is possible in the dating. As an example the dating problems of Pyramid Valley are discussed. J. M. HOUGH

550.93 : 539.16.08

903. Copenhagen natural radiocarbon measurements. I. E. C. ANDERSON, H. LEVI AND H. TAUBER. *Science*, **118**, 6–9 (*July* 3, 1953).

See preceding abstract. Similar work in Copenhagen is described but includes a modification in the counter technique to permit the simultaneous determination of background and actual counts, using a double screen wall counter. The instrument has been used for dating the Alleröd period, and it is shown that the results are highly consistent despite differences in geographical location and the chemical composition of the sample. J. M. HOUGH

550.93 : 539.16.08

904. Radiocarbon dating of the Alleröd period. J. IVERSEN. *Science*, **118**, 9–12 (*July* 3, 1953).

The data of the preceding abstract is compared with pollen analysis, and it is shown that samples of the same age by pollen analysis are of the same age by radiocarbon analysis despite the samples being wood or calcareous. An agreement with data from Swedish carved clay is also recorded for one sample. Data from Britain, Germany and N. America also show that events at this period believed contemporary from pollen analysis are also contemporary for radiocarbon dating. J. M. HOUGH

550.93 : 539.16.08

905. Age determination of uranium minerals by the Pb^{210} method. J. L. KULP, W. S. BROECKER AND W. R. ECKELMANN. *Nucleonics*, **11**, 19–21 (*Aug.*, 1953).

Ages have been determined by estimating the ratio of Pb^{210} to Pb^{206} present in the minerals. The Pb^{206} was determined by mass spectrometer analysis, and the Pb^{210} determined by α-counting the Po^{210}, after allowing a sufficient time for the Po activity to build up and other interfering activities to decay. Results of comparisons of mineral ages calculated by this method, with ages determined by the ratios Pb^{206}/U^{238}, Pb^{207}/U^{235}, Pb^{208}/Th^{232} and Pb^{207}/Pb^{206} are tabulated. L. R. SHEPHERD

551.1 : 536.421

906. The melting of iron at high pressures. F. E. SIMON. *Nature* [*London*] **172**, 746–7 (*Oct.* 24, 1953).

Information on the variation of melting pressure of iron with temperature would assist certain geophysical research. A semi-empirical relation between melting-point and internal pressure was applied qualitatively to the case of Fe in 1929. Recently (1952), the formula has been given a theoretical foundation, and new experiments have provided for the first time reliable data for the heat of fusion, and volume change of Fe. Making the three following assumptions: (i) that the body-centred cubic δ modification of Fe will be stable at the highest temperatures considered; (ii) no critical point occurs between solid and fluid phases; (iii) no change of electron configuration in the outer shell of the Fe atom takes place at very high pressures, it is found that for a core of pure Fe equilibrium temperature at the 5000 km discontinuity within the earth will be $\sim 3900°K$, and at the centre > 4000 K° if the core is liquid. D. R. BARBER

ATMOSPHERE . METEOROLOGY 551.5

551.510.41 : 551.593.5

907. The vertical distribution of nitrous oxide and methane in the earth's atmosphere. L. GOLDBERG AND E. A. MÜLLER. *J. Opt. Soc. Amer.*, **43**, 1033–6 (*Nov.*, 1953).

The intensities of the atmospheric lines *P*25, *P*26, *P*27, and *P*29 of the 2·16-μ band of N_2O and of the 5–6 line of the 1·66-μ band of CH_4 have been measured in the spectrum of the low-sun observed from Mount Wilson. For both molecules, the rate of change of intensity with solar zenith angle is inconsistent with the existence of these gases in thin layers at altitudes of 15 km or greater. On the other hand, the observations satisfy very well the assumption of uniform mixing with the major constituents of the atmosphere. A.

551.510.41 : 551.593.5

908. Investigations of atmospheric CO at the Jungfraujoch. W. BENESCH, M. MIGEOTTE AND L. NEVEN. *J. Opt. Soc. Amer.*, **43**, 1119–23 (*Nov.*, 1953).

Analysis of high-resolution solar spectra taken at the Jungfraujoch in Switzerland indicates that the terrestrial atmospheric CO content may vary by a factor of five in extreme cases, and is, furthermore, subject to surprisingly large fluctuations within the period of one hour. These variations are apparently unrelated to the more readily available data on general meteorological conditions, but a mechanism is suggested wherein the fluctuations of the CO may depend on atmospheric irregularities of a more finely detailed nature than those which normally come into consideration in meteorological observations. A.

551.510.535

909. The structure of the *F* region of the ionosphere. A. A. WEISS. *Austral. J. Phys.*, **6**, 291–303 (*Sept.*, 1953).

The effects of temperature cycles, of a decay coefficient non-uniform with height, and of vertical tidal drifts upon the structure of the *F* region of the ionosphere are considered. Special attention is devoted to the behaviour of the level at which the maximum electron density occurs. Both decay by recombination and decay by attachment are examined. It is concluded that the diurnal and seasonal height

variations of the F_2 region are not the result of vertical tides alone acting on an isothermal Chapman region. A qualitative explanation of these variations is obtained by postulating, in addition, a diurnal temperature cycle, provided the decay coefficient does not change rapidly with height. Under the alternative hypothesis, that a single ionization process forms both F_1 and F_2 regions by bifurcation when the decay coefficient changes rapidly with height, the height variations appear to require discontinuities in the height gradient of the decay coefficient; tidal drifts are still necessary, but a diurnal temperature cycle, if it exists, is not of major importance. A.

551.510.535 : 621.396.11

910. The ionosphere; its significance in geophysics and radiocommunications. [Die Ionosphäre. Ihre Bedeutung für Geophysik und Radioverkehr.] K. RAWER. *Groningen: P. Noordhoff N.V.* (1953) 189 *pp. In German.*

Review in *Nature* [*London*] **172**, 514 (*Sept.* 19, 1953).

551.513

911. Buoyant motion in a turbulent environment. C. H. B. PRIESTLEY. *Austral. J. Phys.*, **6**, 279–90 (*Sept.*, 1953).

Solutions are given of the simultaneous equations for the vertical velocity and temperature of an element of fluid moving under buoyancy and subject to continuous mixing of heat and momentum with its environment. Three distinct modes of behaviour result: (A) ascent followed by damped oscillations, (B) asymptotic ascent to an equilibrium level, (C) absolute buoyancy in which the ascent rate increases indefinitely. For an environment in which the lapse rate is subadiabatic the motion is of type A for sufficiently large elements but may become B for the smaller elements; in superadiabatic lapse rates the mode is C for sufficiently large elements, and B for the smaller elements, which are in no way unstable. The mode of motion is independent of the initial conditions but the scale of the motion is not. The same formulation applies within known limits to the ascent of saturated air, and applications made to atmospheric convection include the verification of a formula for the period of large cloud tops oscillating in a stable layer. A.

551.574

912. The identification of individual hygroscopic particles in the atmosphere by a phase-transition method. S. TWOMEY. *J. appl. Phys.*, **24**, 1099–102 (*Sept.*, 1953).

It is shown that in many cases the measurement of the relative humidity at which a hygroscopic particle becomes liquid can be used to establish the chemical composition of the particle. An apparatus is described which produces a stream of air of constant temperature and variable humidity. Using this apparatus the phase-transition point was determined for particles collected on spider webs. These particles were sampled in the Sydney area on the ground and from an aircraft, and it is shown that the measured values of relative humidity for the solid-liquid phase transition agreed with the hypothesis that the hygroscopic particles were composed of sea salt. Direct microscopic observation was used to follow the behaviour of the particles; the technique was capable of dealing with particles down to 10^{-12} g. A.

551.593.55

913. Brightness and color of the twilight sky. E. V. ASHBURN. Letter in *J. Opt. Soc. Amer.*, **43**, 805–6 (*Sept.*, 1953).

The incompleteness in several aspects of Hulbert's interpretation [Abstr. 2852 (1953)] of the observed colour-temperature, and brightness of the zenith twilight is stressed; and an indication is given of certain experimental facts (not considered by Hulbert) which might well strengthen, and even verify the interpretation. D. R. BARBER

551.593.9

914. A four-year study of [O I] 5577 Å in the nightglow. F. E. ROACH, H. B. PETTIT, D. R. WILLIAMS, P. ST. ARMAND AND D. N. DAVIS. *Ann. Astrophys.*, **16**, *No.* 4, 185–205 (1953).

A systematic survey is made of 66 nights of observation of [O I] 5577 at Cactus Peak, California, from Nov., 1948, to Dec., 1952. The mean intensity of the radiation varies from 50×10^6 to 350×10^6 quanta/cm^2 column-second. The minimum and maximum intensities and the general level of activity $\propto$ the mean intensity. No correlation between sunspot activity and the intensity of 5577 is found. There is a seasonal variation with a maximum in September to November and a flat minimum in May to July. A negative correlation between magnetic activity (K_p) and 5577 activity is indicated. A comparison of results from 17 nights at the Haute Provence Observatory with the Cactus Peak data indicates that the region of maximum intensity tends to be predominantly to the south at Haute Provence and somewhat to the north at Cactus Peak. The data suggest the existence of an excitation wind moving from east to west in the evening, stopping during the middle hours (near the time of maximum intensity) and moving from west to east with a strong southerly component in the morning. A.

551.593.9 : 535.338.4–15

915. Spectrum of the night sky in the range, 1·2–2 μ. A. V. JONES AND H. GUSH. Letter in *Nature* [*London*] **172**, 496 (*Sept.* 12, 1953).

A summary of results obtained at Saskatoon, Canada, in June, 1953, using a PbS cell as receiver in the infrared region, 1–2 μ. A 7–56 Corning filter eliminated radiation of wavelengths $< 0{\cdot}9\ \mu$. A striking feature is the strong emission near $1{\cdot}5\ \mu$, attributed to the $\Delta v = 2$ sequence of the OH rotation-vibration bands of which the higher sequences were discovered by Meinel (1950). Between $1{\cdot}2\ \mu$ and $2\ \mu$ bands observed agree well with known positions of OH bands: below $1{\cdot}2\ \mu$ agreement is poor, due possibly to distortion from low-level auroral radiations. D. R. BARBER

551.593.9 : 535.35

916. Production of sodium airglow excitation by imprisonment of resonance radiation. A. FODERARO AND T. M. DONAHUE. Letter in *Phys. Rev.*, **91**, 1561 (*Sept.* 15, 1953).

To account for the *D*-line emission observed in the night-sky at heights where the number-density of Na atoms is low, the theory of imprisoned resonance

radiation due to Holstein [Abstr. 9387 (1951)] has been used in a modified form. For a spherical shell of atmospheric Na exposed to scattered sunlight, 100 km thick and at 300°K, density 10^{11} atoms per cm^2 column, a photon radiated upwards from the base will have a probability of capture equal to 0·84. On this theory the observed excitation on the night-side of the earth may be explained as due to transport of imprisoned resonance quanta from the sunlit side. It is further suggested that it may be invoked also to account for the excitation of resonance lines of atoms other than Na. D. R. BARBER

551.594

917. On the measurement of the electrical potential gradient in the upper air over Poona by radiosondes. S. P. VENKITESHWARAN, N. C. DHAR AND B. B. HUDDAR. *Proc. Indian Acad. Sci. A*, **37**, 260–7 (*Feb.*, 1953).

Describes the modification of an American type radiosonde to accommodate a Koenigsfeld and Piraux electrometer [Abstr. 8375 (1951)]. Collectors of both the lead nitrate fuse and polonium types have been used in the few preliminary measurements so far reported. J. M. HOUGH

551.594

918. Measurement of the electrical conductivity in the upper air by radiosonde. S. P. VENKITESHWARAN, B. K. GUPTA AND B. B. HUDDAR. *Proc. Indian Acad. Sci. A*, **38**, 109–15 (*Aug.*, 1953).

See preceding abstract. Work has been extended to the measurement of the conductivity of the upper air due to positive ions by the use of a Gerdien condenser in conjunction with the radiosonde electrometer. Preliminary results seem to be consistent with those obtained by previous workers. J. M. HOUGH

551.594

919. Apparatus and methods of measurement for atmospheric electrical investigations. I. Survey. H. ISRAEL. *Arch. tech. Messen, Issue No.* 211 (*Ref. V*656–2) 171–4 (*Aug.*, 1953) *In German.*

A summary of the general principles on which the measurements depend and a very brief outline of the different measurement techniques. J. M. HOUGH

551.594.14

920. On the radioactive contamination of the atmosphere. O. HAXEL AND G. SCHUMANN. Note in *Naturwissenschaften*, **40**, *No.* 17, 458–9 (1953) *In German.*

The results of the use of the filter designed by Haxel [Abstr. 8646 (1953)] show that the activity of the atmosphere at a height of 565 m on the Königsstuhl near Heidelberg varies with the particular air mass passing over. The onset of a period of extraordinary activity due to an atomic explosion can be calculated easily from data showing the decay of this activity with time. It is shown that a particular explosion at Las Vegas took 7 days to arrive. J. M. HOUGH

551.594.14

921. Prospecting the radioactivity of the air. H. GARRIGUE. *C.R. Acad. Sci.* [*Paris*] **237**, 802–3 (*Oct.* 12, 1953) *In French.*

Lists the most recent French measurements made in an aerial laboratory and on the summit of the Puy-de-Dôme. Shows the existence of a strong source of radioactivity at about August 15th. J. M. HOUGH

551.594.221

922. The electric charge neutralized by the lightning discharge. H. HATAKEYAMA. *J. Geomag. Geoelect.*, **1**, 4–6 (*March*, 1949).

From simultaneous records of aerial discharge currents at two or more points in Japan it is deduced that, during the mature stage of a thundercloud, charges up to 300 or 400 coulombs are neutralized while corresponding figures during the decay stage of the cloud are generally less than 50 coulombs. Similarly the distances between charge concentrations decrease from ~ 4 km for charges involving 300 coulombs to ~ 1 km for charges of 10–20 coulombs. Large negative electric field changes are identified with the decay period of a storm and are believed to be due mainly to horizontal discharges in contrast to vertical discharges during the mature stage. R. H. GOLDE

551.594.5

923. Magnetic self-focusing of auroral protons. W. H. BENNETT AND E. O. HULBURT. Letter in *Phys. Rev.*, **91**, 1562 (*Sept.* 15, 1953).

A stream of protons and electrons ejected from the sun in a wide angle cone will rapidly focus itself into a stream having a diameter of the same order as that of an auroral display, and will be bent into the auroral zones by the earth's magnetic field (according to the Birkland–Störmer theory). G. M. BROWN

551.594.5 : 535.33

924. The intensities of atomic and molecular features in the auroral spectrum. W. PETRIE AND R. SMALL. *Canad. J. Phys.*, **31**, 911–26 (*Sept.*, 1953).

A considerable number of auroral spectrograms (dispersion 85–28 Å/mm) have been analysed with a recording microphotometer, and integrated intensities obtained for the main features. Relative population rates of the relevant levels are determined from the measured intensities. Excitation mechanisms are discussed and the absence from the spectra of certain low level atomic lines does not appear to be anomalous. It seems that atomic lines are emitted as the results of several processes, while the ionic lines are produced during simultaneous ionization and excitation through electron exchange. Vibrational temperatures of First Negative, First Positive and Second Positive nitrogen bands are computed. A.

551.594.5 : 551.593.9

925. A note on auroral motions. A. B. MEINEL AND D. H. SCHULTE. Note in *Astrophys. J.*, **117**, 454–5 (*May*, 1953).

Visual observations of aurorae reveal that individual ray and streamer formations show a pronounced westward drift which has been interpreted as due to an effect of the earth's diurnal rotation under an excitation pattern fixed with respect to the earth-sun axis. This explanation is now proved erroneous by the results of photographic sequence-records made with 16 mm cine-equipment working at *f*2 with Eastman 103a–F film, exposure times being about 1 min. The records show that the motion of auroral features, westerly during the evening hours, is

easterly after local midnight. The new interpretation envisages a circulatory system in the ionosphere capable of transporting the excitation pattern; and implies a single circulation cell in the atmosphere above 100 km.

Diurnal variation of [O I]5577 in the nightglow. F. E. ROACH, D. R. WILLIAMS AND H. B. PETTIT. *Ibid.*, 456–60.

This note describes somewhat similar features for the motion, and intensity variation of the 5577 radiation from the nightglow. In this case, motion of the excitation pattern prior to attainment of max. intensity (usually in the early morning hours) is westerly. Around luminosity maximum the pattern is static, the subsequent motion consisting in a small easterly component, with a large southerly component superposed. The results are based on two sets of detailed records obtained on the nights of January 6–7, 1951, and November 19–20, 1952. D. R. BARBER

551.594.6 : 621.3.018.7 : 621.396.821

926. Audio-frequency spectrum of atmospherics. F. W. CHAPMAN AND W. D. MATTHEWS. Letter in *Nature* [*London*] **172,** 495–6 (*Sept.* 12, 1953).

Some results obtained from the simultaneous recording of the relative amplitudes of the different frequency components in the spectrum of atmospherics are given. The frequency of the largest component in the "slow-tail" of the waveform decreases with increasing distance from the source, whereas for the higher frequency oscillatory portion the opposite effect occurs. A brief comparison is made with the results of other workers.

W. J. G. BEYNON

551.594.6 : 551.594.221 : 621.3.018.7 : 621.396.821

927. The wave form of atmospherics in daytime. A. KIMPARA. *J. Geomag. Geoelect.*, **1,** 14–16 (*March,* 1949).

From oscillographic records of atmospherics, frequency distribution curves are derived showing that the frequency of the first oscillation in the highly damped oscillatory train produced by the return stroke of a lightning discharge to earth varies from ~3 to 15 kc/s with a pronounced max. at 7·5 kc/s and that the duration of the oscillatory train has a max. of ~ 600 μsec although durations up to 3000 μsec have been observed. Brief mention is made of other types of atmospherics. R. H. GOLDE

BIOLOGY 57/59

576.8 : 535.343–15

928. Infrared spectroscopy in bacteriological research. H. M. RANDALL AND D. W. SMITH. *J. Opt. Soc. Amer.*, **43,** 1086–92 (*Nov.*, 1953).

The possible uses of the complex mixtures of compounds found in viruses (the tobacco mosaic virus) or in bacteria (the tubercle bacillus or extracts of these organisms), have been studied. It was found that the procedures of inoculation, growth, harvesting and fractionation into simpler mixtures should be standardized. This resulted in characteristic composite spectra for each fraction. The following uses have been established for infrared spectroscopy in this field: (1) A control on the techniques of operation; (2) the discovery of the spectroscopic differences between strains which may or may not be recognized as biologically different; for example, spectroscopic differences between virulent and avirulent strains of the standard laboratory strain H37, or spectral differences between human and bovine varieties of tubercle bacilli and spectral differences between strains recently isolated from patients ill with pulmonary tuberculosis; (3) spectroscopic interpretation of molecular content. A.

577.1

929. Some applications of de Broglie mechanics to biology. R. DAUDEL. *Cahiers de Phys., No.* 44, 15–43 (*July*, 1953) *In French.*

A review article which outlines the study of conjugated molecules by wave mechanical techniques with special reference to the treatment of polycyclic carcinogens. A brief résumé of Wheland's localization method shows how the charge density at an atom may be related to the energy required to provide electrons at the position of attack, and in particular how addition reactions may be related to the sum of these quantities for the two atoms concerned. The application to polycyclic hydrocarbons is treated historically beginning with Schmidt's hypothesis associating a catalytic activity by such molecules in gene mutation with the existence of regions of high electron density. Svartholm's emphasis on the importance of addition at the meso-phenanthrenic 3–4 bond of 1–2 benzanthracene is considered, and Pullman's work on the relation between activity and the calculated charge density in this region is briefly mentioned. That the region favours addition reactions is shown by Badger's work on the addition of OsO_4. The metabolism of these molecules often results in oxidation not at the most active 3–4 region, but elsewhere, suggesting that the bond may be blocked to oxidation by reason of its function as a means of attachment to some element of cell structure.

H. H. GREENWOOD

577.3

930. A physical interpretation of the biological field. J. WINTER. *Cahiers de Phys., No.* 44, 5–14 (*July*, 1953) *In French.*

A descriptive survey of the theory which seeks to explain action at a distance in biological systems by means of a biological field of force. The theory is based upon the model of a system of chains of resonating oscillators. The oscillator consists of a water molecule vibrating in the small free space it may occupy. The phenomenon at the basis of the theory is the resonance between two such adjacent oscillators which gives rise to a condition of greater stability. Resonant chains of increased stability are formed by permitting the interaction of paired oscillators and further stability may be attained by

the mutual resonance interaction of geometrically similar chains. The plausible length of a chain remains much less than the distances over which biological influences are felt. Van der Waerden's theory of the transfer of order in a crystal to large distances is therefore invoked to explain the influence of a group of resonating chains at large distances. It is assumed that a biological macromolecule may impose upon the liquid medium a system of vibrations, thus giving rise to the resonance chains within the medium. It follows that an ordered medium may likewise influence a macromolecule and in particular by a specific interaction. The liquid medium may therefore play a fundamental role in the interaction over large distances of biological systems.

H. H. GREENWOOD

578 : 519.282 : 537.542

Statistics of blood-cell counter. *See Abstr.* 549

578 : 539.166

Measurement of the γ-radiation from the human body. *See Abstr.* 729–30

578.084 : 534.321.9

931. On ultrasonic pictures of the human skull. W. GÜTTNER, G. FIELDER AND J. PÄTZOLD. *Acustica*, **2**, *No.* 4, 148–56 (1952) *In German.*

The testing of Dussik's ultrasonic method for outlining the ventricles of the brain in life leads to a number of difficulties. The chief are: (1) The damping produced by the ventricles is small compared to that of the brain and the bones. The spherical form of the cranium produces refraction, and distortion in the ultrasonic picture. (2) The variations in thickness of the cranium produce a picture which depends so much on its structure that it masks the attenuation in the ventricles. A study of these disturbing effects shows that it is not really possible to outline the ventricles by means of the Dussik projection method. A.

578.087 : 535.33.07–15

Goniometric spectrometer for the measurement of diffuse reflectance and transmittance of skin in the infrared spectral region. *See Abstr.* 247

578.087 : 621.375.233.024

932. Development of a high-fidelity preamplifier for use in the recording of bioelectric potentials with intracellular electrodes. S. J. SOLMS, W. L. NASTUK AND J. T. ALEXANDER. *Rev. sci. Instrum.*, **24**, 960–7 (*Oct.*, 1953).

In the intracellular recording of action potentials, the fidelity of recording is limited by the resistance and capacitance of the ultramicroelectrode required for making connection to the intracellular contents, and by the characteristics of the input circuit of the amplifier. The cathode follower circuit conventionally used to minimize the time constant of the recording system is discussed and its shortcomings are analysed. An improved circuit involving positive feedback is presented. The measurement of the recording system time constant is discussed. A.

578.087.87 : 621.373.44

933. An electronic stimulator controlled by biological potentials. P. L. BONFERRONI AND M. CONVERSI. Note in *Nuovo Cimento*, **10**, 835–42 (*June*, 1953) *In Italian.*

This is designed to reproduce feedback mechanisms, normally connected with the activity of the central nervous system. At each triggering pulse, the stimulator yields a series of rectangular pulses which are variable, within wide limits, in number, amplitude and width. A variable delay (from 0 to 2000 msec may be also introduced, with respect to the bioelectric signal. An example of application is shown, and some circuits are described in detail. A.

578.088 : 535.343.3–15

Infrared spectroscopy of biologic materials in aqueous solutions. *See Abstr.* 286

591.185.5 : 612.85

934. High frequency auditory response of a bottlenosed porpoise, *Tursiops truncatus* (Montagu). W. E. SCHEVILL AND B. LAWRENCE. Letter in *J. Acoust. Soc. Amer.*, **25**, 1016–17 (*Sept.*, 1953).

Conditioned responses of a bottlenosed porpoise (*Tursiops truncatus*) showed its upper frequency limit of auditory response to be about 120 kc/s. The analogy of human bone-conduction ultrasonic "hearing" is considered. Some aspects of phonation and echo-location are commented on. A.

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.014.48

935. Some facts concerning radiation biology. W. SUMMER. *Atomics* [*London*] **4**, 258–62 (*Oct.*, 1953).

The radiation hazard, present accepted levels of human tolerance for radiations and basic biochemical and physical processes occurring in irradiated tissues are reviewed in general terms. Some physical properties of commonly used radioisotopes are tabulated, and isotopes suitable for use in large sources for teletherapy are indicated. D. V. MABBS

612.84

936. Quantum and noise limitations of the visual process. A. ROSE. *J. Opt. Soc. Amer.*, **43**, 715–16 (*Sept.*, 1953).

A set of photographs is presented that gives a direct measure of the quantum limitations of the visual process at low illuminations. A.

612.843

937. The luminosity curve as affected by the relation between rod and cone adaptation. C. S. BRIDGMAN. *J. Opt. Soc. Amer.*, **43**, 733–7 (*Sept.*, 1953).

Previous experimental determination of the luminosity curve of the eye at intermediate intensities has shown a series of transitional curves intermediate between rod and cone, the appearance of which has been attributed to rod-cone interaction. However, examination of mesopic curves predicted on the basis of no interaction indicates that their major characteristics are dependent instead on the relation between rod and cone functional levels. Residual discrepancies between predicted and empirical curves require the assumption of summation between the two mechanisms at wavelengths for which sensitivity is nearly equal for both. In addition to contributing to an understanding of relations between rod and cone function, the analysis emphasizes the lack of validity of mesopic curves for photometric calculations. A.

612.843

938. The instantaneous threshold and early dark adaptation. H. D. Baker. *J. Opt. Soc. Amer.*, **43**, 798–803 (*Sept.*, 1953).

The luminance threshold for a white test field, 1° in diameter, was measured before, coincident with, and immediately after the extinction of white adapting fields of various luminance levels. Foveal and parafoveal measurements were made on several subjects. The threshold begins to rise about 0·2 sec before the onset of darkness, rises to a maximum at about the time of darkness, then falls in the dark-adaptation curve. The early part of the dark-adaptation curve shows an initial very rapid drop, whose slope may be different for rods and cones. The theoretical implications of the data, especially the anomalous threshold rise, are considered with respect to their general bearing on Hecht's photochemical theory. A.

612.843

939. A functional interpretation of the Stiles-Crawford effect. L. H. Beck. Letter in *J. Opt. Soc. Amer.*, **43**, 924 (*Oct.*, 1953).

It is suggested that the Stiles-Crawford effect is corrective, reducing the blurring of the retinal images due to stray light. R. A. WEALE

612.843.31

940. Color perception in small test fields. R. W. Burnham and S. M. Newhall. *J. Opt. Soc. Amer.*, **43**, 899–902 (*Oct.*, 1953).

Several small test colours were varied in size and shape to discover possible effects on their colour appearance. Colour appearance was evaluated colorimetrically with a binocular septum viewer; the test colour was viewed with one eye under the given conditions and matched with a variable mixture presented to the other eye under standard conditions. Increasing the area of the test colours from 25 to 500 sq. min of visual angle evoked some significant increases in saturation and characteristic shifts in hue. These changes in perceived colour were found to be independent of marked changes in rectangular shape. The observed changes are related to small area tritanopia. A.

612.843.37

941. Scotopic vision and its relation to the quantization of light. H. Gobrecht and H. Oertel. *Z. Phys.*, **135**, *No.* 5, 541–52 (1953) *In German.*

A simple statistical calculation and the use of experimental data—some of which are not universally accepted—lead to a reconciliation between the bi- and polyquantal explanations of the absolute visual threshold. The general expression contains Ricco's and Piper's laws and the constancy of the product intensity × time, if the latter does not exceed 0·1 sec. The differential threshold is shown to be only little greater than "quantal scatter." The observed variation of the receptive field with wavelength agrees with that predicted by theory. R. A. WEALE

612.843.37

942. The optical density of the photosensitive pigments of the eye and the mechanism of adaptation. J. Ségal. *Rev. Opt.*, **32**, 385–404 (*July*, 1953) *In French.*

The optical density of visual purple in the external parts of rods is determined by two objective methods. The obtained value is $d = 0{\cdot}8$ to $1{\cdot}0$. These data seem to be contradictory to those given by a subjective method. The analysis of this apparent discrepancy leads to the conception that a double mechanism in photochemical adaptation exists in the eye: one based on local exhaustion of visual purple, the other one on its exhaustion in the whole of the external part. The limit between the two types of adaptation seems to be about 6000 Troland units. Many facts in man and in animal indicate a profound modification in visual function when this limit of intensity is passed; this confirms the hypothesis of a change in the adaptation mechanism for high levels of intensity. A.

612.843.37

943. Measurement of accommodation in dim light and in darkness by means of the Purkinje images. J. M. Otero. *J. Opt. Soc. Amer.*, **43**, 925 (*Oct.*, 1953).

Koomen, Scolnik and Tousey's data [Abstr. 2109 (1953)] are criticized on the ground that their use of a fixation light may have caused a "far accommodation" artefact. The author worked without a fixation mark and his results are confirmed by Carrera's recent work which shows that accommodation of 1·5–2·0 dioptres is a characteristic of night myopia. R. A. WEALE

612.843.37

944. Twilight myopia. F. W. Campbell. *J. Opt. Soc. Amer.*, **43**, 925–6 (*Oct.*, 1953).

Experiments similar to Koomen, Scolnik and Tousey's (see preceding abstract) were done on 13 subjects, the principal difference being the use of a scotopic stimulus to direct the subject's gaze. In all cases the refractive power of the lens increased, the mean being $0{\cdot}64D$. A similar change was found to occur when the eye faced a larger bright field without any visual detail. R. A. WEALE

612.843.37

945. Accommodation and night myopia. R. Tousey, M. Koomen and R. Scolnik. *J. Opt. Soc. Amer.*, **43**, 926–7 (*Oct.*, 1953).

In reply to Otero's and Campbell's comments (see preceding abstracts) the authors state that the accommodation of the eye is the same both in dim light and in darkness, that spherical and chromatic aberration will explain it completely, and that they never found significant fluctuations. Results, contrary to theirs, as obtained by Otero, and Wald and Griffin with subjective methods, are probably due to the inexperience of their observers. Carrera's data are considered as being dubious since no value for the luminance of the test-field is quoted. R. A. WEALE

612.843.613

946. Absolute thresholds for moving point sources. M. A. Bouman and G. van den Brink. *J. Opt. Soc. Amer.*, **43**, 895–8 (*Oct.*, 1953).

The theoretical treatment of absolute and contrast thresholds for moving point sources is presented. The thresholds are tested as functions of the velocity v and observation time t on the assumption that, under all conditions for minimum perceptibility, p quanta must be effectively absorbed in the retina within τ

seconds the δ minutes of arc; within τ and δ the integrate capacity in time and space of the sense organ is complete. p, δ and τ depends on the particular condition of colours of the light used, state of adaptation, place of the retina, and the like. For absolute thresholds in the dark-adapted eye, $p = 2$ quanta independently of the colour of the test stimulus. The behaviour of experimental data for absolute thresholds of green and red moving point sources is also in agreement with the dependences deduced from theory when $p = 2$. The data were obtained at retinal positions 7° nasal to the fovea in the dark-adapted right eye. A.

612.843.63

947. Some observations and theory on the variation of visual acuity with the orientation of the test object. H. Leibowitz. *J. Opt. Soc. Amer.*, **43**, 902–5 (*Oct.*, 1953).

The superiority of visual acuity obtained with a grating test object oriented vertically or horizontally over values obtained with oblique orientations is demonstrated for various combinations of pupil diameter and retinal illuminance level. This superiority, which has an average value of 7% of the mean threshold angle of resolution for all meridians, increases with pupil diameter but is not affected systematically by illuminance level. The data are discussed with reference to the assumptions that meridional differences in acuity are a result of dioptric or of retinal factors. The systematic effect of pupil diameter points to the dioptric origin of some of the observed meridional differences. The influence of retinal or post-retinal factors as well is suggested by the persistence of the effect at a high illuminance level and with large pupil diameters, a condition where a slight decrease in retinal image contrast is shown not to lower acuity. A.

612.843.721

948. The role of convergence in stereoscopic vision. K. N. Ogle; W. D. Wright. Letters in *Proc. Phys. Soc.* [*London*] *B*, **66**, 513–15 (*June*, 1953).

Criticizing a conclusion of Wright's [Abstr. 5950 (1951)], Ogle points out that when stereoscopic acuity is measured without enforcing fixation the same result is obtained as when fixation is maintained but the angle θ between the two test-objects is doubled. He deduces that convergence movements, unlike the disparity of the retinal images, are unnecessary for stereopsis. In reply, Wright points out that if, in the absence of enforced fixation, pseudo-fixation occurred half-way between the test-objects, the blind spot could not have affected the value for stereoscopic acuity at $\theta = 14°$. R. A. WEALE

612.843.721

949. The Luneburg theory of binocular visual space. A. A. Blank. *J. Opt. Soc. Amer.*, **43**, 717–27 (*Sept.*, 1953).

A theoretical treatment of binocular space perception based on the methods of R. K. Luneburg. A simplified axiomatics is employed. New experimental results are brought within the framework of the theory. The experimental evidence is seen to support Luneburg's hypothesis as to the hyperbolic character of visual space. The relation between visual and physical co-ordinates proposed by Luneburg is found to hold only as a special case of a more general transformation. A.

612.843.721

950. Precision and validity of stereoscopic depth perception from double images. K. N. Ogle. *J. Opt. Soc. Amer.*, **43**, 906–13 (*Oct.*, 1953).

Reports data on the question as to how precise is stereoscopic depth localization with double images and what is the relationship between that subjective depth and objective depth. Instrumentation was used which permitted a test object to be adjusted relative to a reference object, when both of these were observed in increasing disparity between the images of the two eyes and in increasing peripheral angle. The data show that the precision of the stereoscopic depth seems to decrease exponentially with disparity, becoming very small near the limiting values of disparity for stereopsis. When the test object is adjusted for half the depth of the reference object, and adjusted to be as far in front of the fixation point as the reference is behind, the data show a remarkable validity for a wide range of disparity, until the limiting disparities are approached. Then the stereoscopic depth levels off to a constant value. These results are discussed in relation to the visual processes and spatial localization. A.

612.845

951. The convergence of the tritanopic confusion loci and the derivation of the fundamental response functions. L. C. Thomson and W. D. Wright. *J. Opt. Soc. Amer.*, **43**, 890–4 (*Oct.*, 1953).

The colour matching characteristics for tritanopia reported in Abstr. 7785 (1952) have been used to make a new determination of the tritanopic confusion loci. These loci cut the spectrum locus twice, once in the yellow-green and once in the blue and violet, and their point of convergence has been located in the chromaticity chart for a modified C.I.E. observer. Using two other stimuli similar in position to the "red" and "green" fundamental stimuli found by Pitt and Walters, new fundamental response curves have been calculated. A.

612.85

952. On the DL for frequency. W. A. Rosenblith and K. N. Stevens. *J. Acoust. Soc. Amer.*, **25**, 980–5 (*Sept.*, 1953).

Difference limens for three frequencies (250, 1000 and 4000 c/s) were determined for two trained observers by two psychophysical methods: the ABX procedure and the method of constant stimulus differences or AX procedure. Though the two observers differ considerably in sensitivity, their DL's for the AX procedure are less than one-half of their DL's for the ABX procedure. Comparison of these data with data in the literature on DL's for frequency indicates a wide range of values for different psychophysical procedures and for different subjects. Some observations are reported that illustrate the effect of such factors as practice and ensemble of stimulus conditions upon the size of the DL. The influence of the stimulus ensemble upon judgment time is discussed briefly. In view of all the experimental data, it would be rather imprudent to postulate a

"true" DL, or to infer the behaviour of the peripheral organ from the size of a DL measured under a given set of conditions. While there is undoubtedly some relation between the size of the DL and the so-called channel capacity, there is little reason to assume that the relation is a particularly simple one, given the different operations by means of which these two quantities are determined. A.

612.85 : 534.78

953. Some experiments on the recognition of speech, with one and with two ears. E. C. CHERRY. *J. Acoust. Soc. Amer.*, **25**, 975–9 (*Sept.*, 1953).

Describes a number of objective experiments on recognition, concerning particularly the relation between the messages received by the two ears. Rather than use steady tones or clicks (frequency or time-point signals) continuous speech is used, and the results interpreted in the main statistically. Two types of test are reported: (*a*) the behaviour of a listener when presented with two speech signals simultaneously (statistical filtering problem) and (*b*) behaviour when different speech signals are presented to his two ears. A.

612.858

954. Wave motion in the cochlea caused by bone conduction. J. ZWISLOCKI. *J. Acoust. Soc. Amer.*, **25**, 986–9 (*Sept.*, 1953).

Psychophysical and physiological experiments have shown that a tone transmitted to the cochlea by bone conduction can be compensated by an airborne sound. From these experiments it has been deduced that the vibration pattern of the cochlear partition does not depend upon the path by which sound is transmitted to the cochlea. This hypothesis has been confirmed by direct observation of the vibration pattern in cochlea models and by measurements of cochlear microphonics. From both kinds of experiments attempts have been made to draw conclusions concerning the theory of cochlear dynamics. In an effort to explain the fact that the vibration pattern of the cochlear partition is independent of the path by which the sound is transmitted to the cochlea, a mathematical analysis has been performed. First, by means of the hydrodynamic principle of continuity, it has been demonstrated that the vibration of the cochlear partition caused by a tone introduced into the cochlea either through the bony wall or through an artificial window can be cancelled by a tone transmitted through the oval window, irrespective of the dynamic properties of the partition. Second, a general differential equation of hydrodynamic surface waves has been established, which shows that transverse waves are propagated along the cochlear partition every time there is a difference in pressure between the two sides. According to this equation, the wavelength is independent of the place at which the sound is introduced into the cochlea. Third, it has been deduced from Hamilton's principle of stationary energy that transverse waves in the cochlea must travel from the base towards the apex, irrespective of the location of the sound source. Hence, in agreement with the experiments, the mathematical analysis shows that the vibration pattern of the cochlear partition does not depend upon the way in which sound is transmitted to the inner ear. Furthermore, it shows that the introduction of sound through the bones or through an artificial window does not provide any new clues for the explanation of this pattern. A.

614.898

955. Handling equipment and safety containers for use with isotope γ-ray sources for industrial radiography. D. R. ALLEN, H. S. PEISER AND J. R. RAIT. *Brit. J. appl. Phys.*, **4**, 268–73 (*Sept.*, 1953).

The safe use of active γ-ray isotope sources for radiography in non-destructive testing laboratories requires efficient containing and handling equipment. The design and construction of a complete set of such tools is described. These comprise (*a*) source adaptor, plug and container with trolley for safe storage; (*b*) source-transfer equipment, adjustable rods, stands with quick-release clamps and spider supports for remote handling; and (*c*) special sighting cones and jigs, used prior to positioning the source for exposure, to avoid unnecessary handling. A.

614.898

956. A pressurized γ-radiation monitor for use in inflammable atmospheres. J. B. MARSH, J. F. HOGG AND R. S. CAMBRAY. *J. sci. Instrum.*, **30**, 302–4 (*Sept.*, 1953).

Describes a method of safety control of electrical or electronic units used in explosive gas conditions. Control is obtained by means of a special valve operated by air pressure ensuring adequate flushing of the units before the electrical system is switched on, also protecting the units from accidental shut down of the air supply during working conditions. Results of a test using radioactive gas is given showing the adequacy of flushing. A.

TECHNICAL MATERIALS 66/67

66

957. Looking ahead in mechanics. W. RAMBERG. *J. Washington Acad. Sci.*, **43**, 241–55 (*Aug.*, 1953).

A review of new materials, new methods of design, the mechanical properties of importance in structural design, and the tests (notably fatigue tests) which are required in order to minimize the chance of premature failure. References. J. G. OLDROYD

PHOTOGRAPHY 77

771.31

958. On the depth of focus in photographs. C. V. HOFE. *Optik*, **10**, *No.* 8, 389–98 (1953) *In German.*

Geometrical optical calculations are applied to lenses of selected focal lengths and aperture, with an arbitrary value for the max. acceptable spread of a point in the image plane due to inaccurate focusing. For near objects the short-focus small camera lens

gains in depth of focus over a direct photograph of the same final size made by a longer focus lens. The gain is a factor equal to the enlargement, allowing for the same max. point spread in each final result. This factor increases with increasing distance of the object plane, and with decreasing focal length of the small camera lens. If depth of focus on the camera side of the object plane is alone considered, the factor decreases with increasing object distance. It remains greater for shorter focus lenses, but the advantage is less marked than when total depth of focus is considered. S. T. HENDERSON

771.44

959. The relative photographic efficiency of certain light sources. R. N. WOLFE AND F. H. MILLIGAN. *J. Opt. Soc. Amer.*, **43**, 791–7 (*Sept.*, 1953).

A definition of relative photographic efficiency is given on the basis of the fractional-gradient method of measuring speed (American Standard Z38.2.1-1947). An experimental method of making efficiency determinations accurately on this basis is described and values are given for incandescent tungsten at various temperatures and for commercial tungsten, fluorescent and mercury lamps as well as for the three C.I.E. illuminants and some natural sources. These values are given for typical non-colour-sensitized, orthochromatic and panchromatic materials. A.

771.5

960. Studies in the resolving power of photographic emulsions. VI. The effect of the type of pattern and the luminance ratio in the test object. F. H. PERRIN AND J. H. ALTMAN. *J. Opt. Soc. Amer.*, **43**, 780–90 (*Sept.*, 1953).

For Pt V see Abstr. 7811 (1952). Nine types of resolving-power test-object patterns were compared with the tricolumnar type that has been used for many years. A high-speed, low-contrast film designed for aerial photography was used for all the patterns studied while two patterns were also photographed on a fine-grain, high-contrast film used for microcopying printed matter. All the columnar patterns read practically the same as the tricolumnar one when the line lengths were comparable; when the lengths were less than those of the tricolumnar pattern or when the patterns were of other shapes, lower readings were obtained than for the tricolumnar pattern. This pattern itself gave lower values when the lines were shortened. The Landolt broken-circle pattern was found to be promising for evaluating the ultimate detail-rendering power of an emulsion as distinguished from its resolving power in lines per unit distance. The luminance ratio between the characters and the background of the tricolumnar test object was varied, and it was found that the effect on the resolving power depended upon the emulsion. When resolving power was plotted against the reciprocal of the luminance ratio, the relation was rarely a straight line that would indicate an exponential relation between resolving power and luminance ratio itself; the departures from linearity were similar qualitatively for most materials but different quantitatively. The trend for a given material appeared not to be greatly altered by a considerable change in development conditions. A.

771.531

961. Properties of a new nuclear track emulsion of the Agfa K2 plate. K. LANIUS. *Naturwissenschaften*, **40**, *No.* 12, 338–9 (1953) *In German.*

Performance data, with some comparisons with Ilford and Kodak plates. S. T. HENDERSON

771.534.55 : 612.843.63

962. Psychometric evaluation of the sharpness of photographic reproductions. R. N. WOLFE AND F. C. EISEN. *J. Opt. Soc. Amer.*, **43**, 914–22 (*Oct.*, 1953).

Psychometric methods were used to evaluate the relative sharpness of a number of photographic reproductions in which sharpness was the only significant variable. Since sharpness is an observer's subjective impression of an aspect of picture definition, the methods for deriving sharpness values involve introspective processes and methods of quantifying these subjective impressions. Although no physical measurements of any aspect of the stimulus are involved in deriving sharpness values by the psychometric method, repeated evaluations showed that the scale values obtained are a reliable indication of the sharpness attribute of a photographic reproduction. Three methods of quantifying the judgment data were used, and the sharpness ratings obtained from all three were in good agreement with one another. Projected transparencies gave substantially the same results as paper enlargements. Attempts to correlate the sharpness ratings with physical measurements of some aspect of the developed image were not entirely successful; neither resolving power nor simple density relationships across an abrupt boundary between light and dark areas resulted in satisfactory correlations with sharpness ratings. A.

772

963. On photographic exposure in the infrared according to the method of Czerny (evaporography). H. GOBRECHT AND W. WEISS. *Z. angew. Phys.*, **5**, *No.* 6, 207–11 (1953) *In German.*

A collodion membrane is smoked with soot on one side and an infrared picture projected on to this surface. The other side has a layer of hexadecane evaporated on to it, the whole being kept in an atmosphere of the hydrocarbon, if necessary at reduced pressure. The liquid evaporates according to the intensity of infrared falling on the black surface, and the liquid thus varies in thickness with the energy in the picture. When illuminated the liquid layer reproduces the original object in a range of interference colours which may be photographed. Examples of photographs of warm, dark objects are shown. Calculations on sensitivity and resolving power of the method show that spontaneous evaporation of the liquid is the main limitation. S. T. HENDERSON

778.3

964. Optical systems for underwater photography. A. IVANOFF. *Rev. Opt.*, **32**, 193–202 (*April*, 1953) *In French.*

778.3

965. Photographic science and technique. *Nature* [*London*] **171**, 1143–4 (*June* 27, 1953).

A report on a conference of the Scientific and Technical Group of the Royal Photographic Society held at Manchester in May, 1953. Optical systems

were described for photography in the special cases of measurement of objects at varied distances, of the illumination of cavities, and of high speed work in furnaces. A method of high speed photography by image dissection was described. Other papers dealt with cloud chamber work and the use of nuclear track plates, with references to emulsion behaviour. Wider applications and principles were also considered. A useful paper discussed the legibility of print projected from lantern slides. S. T. HENDERSON

778.3 : 539.164

966. Specific α-radioactivity of Ilford plates for nuclear researches. S. DEUTSCH AND E. C. DODD. Letter in *Nuovo Cimento*, **10**, 858–61 (*June*, 1953) *In French.*

The intrinsic α-particle activity of the C2 emulsion has been reduced by half by (1) demineralization of the gelatine, which removes traces of U, Th and Po, and (2) subsequent washing with distilled water, which removes traces of Ra. Estimates are given of the content of Ra, Th, RaTh, U and Po in the emulsions, and of Th in the glass support. S. T. HENDERSON

778.34

967. Silk threads loaded with uranium in nuclear emulsions. I. Technique, study of the diffusion of the uranium and loss of sensitivity of the emulsion. J. CATALÁ, J. CASANOVA AND F. SENENT. *An. Real. Soc. Españ. Fis. Quim.*, **49**(A), 143–52 (*May–June*, 1953) *In Spanish.*

A new technique is described using uranium-soaked silk threads. The first results deal with the diffusion of the uranium into the emulsion, and with the loss of sensitivity of the photographic grains in the neighbourhood of the threads. The amount of uranium deposited on the threads is checked in order to determine the exposure to the neutron flux required to give enough fissions on the plate. A.

778

968. On induced development alongside nucle tracks in photographic emulsions. J. P. LONGCHA *J. Phys. Radium*, **14**, 433–8 (*July–Sept.*, 1953) *French.*

A detailed account of a theory briefly described Abstr. 2881 (1953) concerning the thickness of tra due to heavy nuclei, based on the number and ra of δ-rays produced along the tracks. Examination fission tracks shows that the observed thickness is due to δ-ray emission, but to the high rate of ene loss. This gives rise to an increased rate of devel ment which results in an increase in thickness co pared with that of a track due to an α-particle. T explanation discounts an alternative point of v that the increased thickness is due to induced devel ment of neighbouring grains. A. C. CO

778.34 : 539.1

The energy spectrum of particles from stars. *Abstr.* 768

778.34 : 539.18

969. Nuclear emulsion techniques for the meas ment of neutron energy spectra. II. L. RO *Nucleonics*, **11**, 38–44 (*Aug.*, 1953).

For Pt I, see Abstr. 8171 (1953). The proble measuring absolute neutron-flux energy distributi using photographic plates both as radiators detectors, is discussed, particular attention b given to the determination of hydrogen concentra in the emulsion, the solid angle of acceptance of proton tracks and the probability that a recoil pro of a given range does not leave the emulsion. factors governing the energy resolution obtained outlined. Applications of the emulsion techniqu the determination of the energies of neutrons em in the $T(d, n)\mathrm{He}^4$ reaction and in inelastic scatte from various elements are described. L. R. SHEPH